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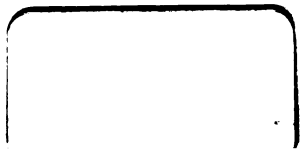

THE

ENCYCLOPÆDIC DICTIONARY

OF

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500 ILLUSTRATIONS.

BY

WALTER E. WOODBURY, F. R. P. S.

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"THE PHOTOGRAPHIC TIMES,"
AND
"THE AMERICAN ANNUAL OF PHOTOGRAPHY."

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"THE ENCYCLOPÆDIA OF PHOTOGRAPHY," "THE GELATINO-CHLORIDE PROCESS," "ARISTOTYPES, AND HOW TO MAKE THEM,"
"RECREATIVE PHOTOGRAPHY,"
ETC., ETC., ETC.

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1896.

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TO
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THE ENCYCLOPÆDIC

DICTIONARY OF PHOTOGRAPHY.

ABAXIAL.—An optical term. Not in the axis.

ABERRATION.—A term used in optics when the rays of light deviate from their normal path, or when the refraction of the rays of the several elementary colors is unequal There are various forms of aberration. The principal ones are known as "Spherical aberration," "Chromatic aberration," "Astigmatism," "Curvature of the field," and Aberration of thickness or distortion.

Spherical aberration is caused by the rays refracted by the margin of the lens meeting at a different point in the axis than those rays which are refracted from the centre. As it proceeds from the sphericity of the surface of the lens it is termed "spherical aberration." The accompanying diagram, Fig. 1, is intended to show the aberration produced by a lens having a spherical surface.* L L is a section of a plano-convex lens, the arrow indicating the line of axis. Now, if the plane side be exposed to the parallel rays A B C D, the extreme rays A D being perpendicular to the plane surface will pass directly through to the convex side, where, upon leaving, they will be refracted to *f*, crossing the axis at that point, and forming an image there. But an image of the object will also be formed at *f'* by the central rays B C, while from *f* to *f'*, the distance of the difference of the central and marginal rays which is termed the longitudinal aberration, images of the same object will be formed by the intermediate portions of the lens. Now, the image formed at *f'* by the central rays is consequently the sharpest, but if we focus on to the screen, the image is surrounded by a halo, G H, caused by the marginal rays A D diverging *after* crossing the axis at *f*, falling on to the screen placed to receive the image of the central rays at *f'*. This halo is termed the lateral spherical aberration, or circle of aberration, and the diameter constitutes the measure or *expression* of the lateral spherical aberration. The aberration produced by a lens of this kind in the manner shown is termed *positive*.

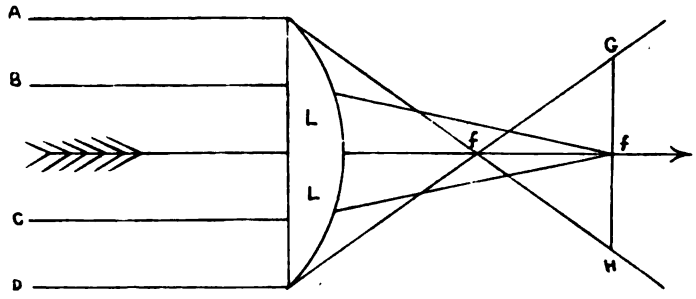

FIG. 1.—DIAGRAM SHOWING EFFECT OF POSITIVE SPHERICAL ABERRATION.

In a concave lens we find an opposite effect takes place. Fig. 2 will explain this. Here we have a plano-concave lens L L, exposed to the convergent rays A B C D. The marginal rays A D are more strongly refracted than the central ones, and in consequence cross the axis denoted by the arrow at *f'*, or farther from the lens than the central rays B C, which have their focus at *f*. So that we have in this case spherical aberration of an opposite character termed *negative*.

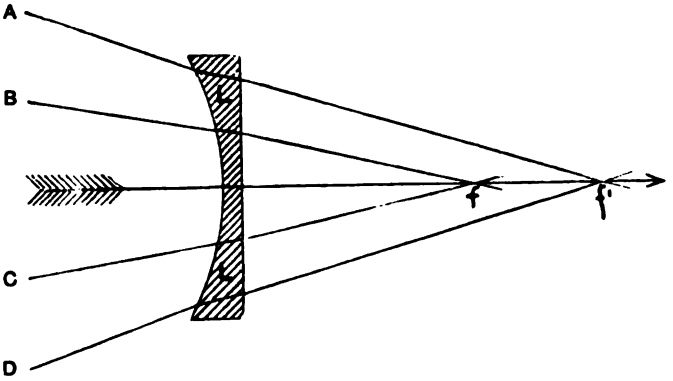

FIG. 2.—DIAGRAM SHOWING EFFECT OF NEGATIVE SPHERICAL ABERRATION.

It will not be difficult to understand that these different images, and the various rays that form them, interfering with and crossing each other instead of meeting at one focus, cause no little confusion and indistinctness of the image, and the larger the aperture of the lens in proportion to its focal length, the greater the defect of spherical aberration, or, in other words,

* In these diagrams the defects are, of course, greatly exaggerated to make them clearer to the student.

the longitudinal spherical aberration * increases as the square of the diameter of the aperture, and inversely as its focal length, while the lateral aberration increases as the cube of its aperture, and inversely as the square of its focal length. It will be seen, then, that if we take two lenses of equal curvature made of the same material, or possessing the same refractive index, the one having an aperture twice the diameter of the other, the longitudinal aberration of the larger one is four times as great, and the lateral aberration is eight times as great as that of the smaller one of only half the aperture. Take two lenses with the same aperture, but let one possess a focal length equal to twice that of the other, the longer one has but one-half the longitudinal and one-fourth the lateral aberration.

We have now to consider the means of correcting this spherical aberration, and the first point that attention must be called to is the curvature of the lens, for the reason that spherical aberration depends upon the sphericity of the surfaces of the lens. The more curved the surface turned toward the parallel rays, the less the aberration. Taking a plano-convex lens, and placing it so that the flat side is directed toward the object, the aberration is 4.5; but if the position is reversed, and the convex side held toward the object, the aberration is reduced to 1.17.† The diaphragm will reduce the defect of spherical aberration very considerably, but never completely destroys it. Now, if we reduce the diameter to one-sixth, we do not alter the focal length of the lens at all, but we have reduced its aperture, so that by what has already been stated with regard to the relation of the aperture to this kind of aberration, we see at once that we have reduced the lateral aberration to one-thirty-sixth.

But in reducing the aperture of our lens in this manner we have also reduced the light, and consequently the rapidity as well, so that it is necessary that the lens should be aplanatic, or free from aberration, when used with full aperture. We have already seen what is meant by positive and negative aberration, Fig. 1 representing the first and Fig. 2 the second. We have also seen that these two aberrations are of an entirely opposite character, the rays refracted near the centre of the lens being refracted farthest from it in the one and nearest to it in the other, so that it will be at once apparent that by combining two lenses of opposite character the defects of one may be counteracted by those of the other. Let us see how this is in practice. In Fig. 3 we have a convergent lens, L L, the aberration of sphericity of which we are anxious to destroy. To it we attach a lens, D D, of an opposite kind, called a divergent lens, and it will be clear that, provided its radii of curvature are suitable, it will scarcely change the central rays, while it will greatly change the directions of the marginal so as to bring them also to a point farther away from the centre of the lens. In other words, the parallel rays A B C D enter into the lens L L, and on emerging would (were the divergent lens removed) find their focus the marginal rays A D at *f*, and the central rays B C at *f'*. But, as shown in Fig. 3, these rays, on leaving the convergent lens, are compelled to enter the divergent one, by which the central rays B C are again refracted from *f'* to F, while the marginal rays A D are refracted from *f* to F, so that the effect of the divergent lens, properly calculated, is to bring all the rays at one focus (F), for the reason that its prismatic form is greater at the margin than at the centre. And if this lens be made of different kind of glass to the convergent, we shall at the same time be able to correct another form of aberration hereafter explained. These two lenses cemented together form a single convergent lens nearly free from spherical aberration, which is termed aplanatic. It is, however, almost a matter of impossibility to so calculate the radii of curvature of the divergent lens as to *entirely* correct spherical aberration; at least, it has never as yet been accomplished.

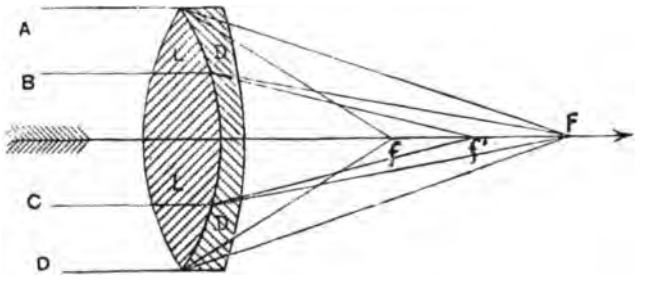

FIG. 3.—SHOWING THE ELIMIATION OF SPHERICAL ABERRATION BY THE COMBINATION OF TWO LENSES OF OPPOSITE CHARACTER.‡

As it is sometimes necessary to test a lens for spherical aberration, the following instructions are given. Cut two small circular pieces of paper and fasten to the window-pane so that they just touch each other; measure the aperture of the lens, and find a stop that will reduce it to one-half. Focus the image of the papers, and carefully examine it by the aid of a focusing glass. Now place the diaphragm into position, and if it is found that when the stop is inserted the image of the paper dots becomes sharper, it is a sign that the aberration has not been completely corrected. It is, of course, necessary that this test should be made along the axis of the lens. If it is necessary to draw back the ground glass of the camera in order to preserve the image as it was before placing in the diaphragm, the lens possesses what is termed *positive* aberration; and if, on the contrary, we have to advance the screen, it has a *negative* aberration.

* The amount of longitudinal aberration is calculated by measuring the difference between the focus of the central rays and that of the marginal.

† "The Optics of Photography," by J. Traill Taylor.

‡ In this diagram the draughtsman has made the lines A B C D pass directly through the double convex lens without being refracted. This is, of course, an error.

For portrait work there are some photographers who prefer to have a lens with the focus slightly diffused. The results are somewhat softer, although this effect can be obtained by a variety of other means.

Chromatic Aberration.—If a ray of light passes through a prism it is split up into its constituent colored rays, and a spectrum is formed. (See Fig. 4.) Now, these colored rays emerging from the prism are unequally refrangible—that is to say, if they fall at the same angle of incidence on the surface of a refracting medium, they will each pursue, in this medium, a different path. The indigo and violet rays are more refracted than the yellow and red, and, in consequence, they are separated from them, occupying a higher position in the solar spectrum. Now, if the prism refracts the blue rays more than the red, and as the outside of a bi-convex lens resembles a prism, it is easily seen that a lens of this description will do the same, and will bring the blue rays to a focus at a point nearer than the red rays, giving what is termed chromatic aberration. The result of this is that we get on the screen a luminous image bounded by colored fringes.

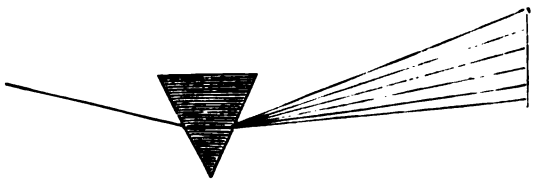

FIG. 4.—SEPARATION OF A RAY OF LIGHT BY A PRISM.

If we take a cheap non-achromatic magnifying glass, and look through it, we shall perceive the same effect. The object is surrounded by all the colors of the spectrum—very pretty to look at, but disastrous to photography.

Now, the causes which produce chromatic aberration tend also to divide the chemical and visual focus. In a photographic lens the parallel rays will be split up and made to meet at different parts, as illustrated in Fig. 5; the violet rays have their focus nearer to the lens than the red. Now, let us see the result. The chemical action corresponds more toward the violet, but the part most luminous to the eye is the yellow. The first is called the *chemical focus*, to indicate its focus as determined by sensitive photographic surfaces, and the latter is termed the *visual focus*, because it indicates the focus of the lens as apparent to the eye. So that, if we focus on the ground glass, we should do so at the visual focus, that is, near the point where the yellow rays meet, and on exposing the plate we should get only a hazy image devoid of sharpness. Therefore, we see that in a lens of this description the visual and the chemical foci do not coincide, and the lens is said to have a chemical focus. It was at one time necessary to focus at the visual point, and then, previous to exposing the plate, to push it forward to obtain the greatest amount of distinct outline in the image impressed by chemical action. But few lenses are now sold that are not achromatized, that is to say, so arranged that the visual and the chemical foci meet at the same point. For a method of testing a lens for achromatism, see **Chemical Focus.**

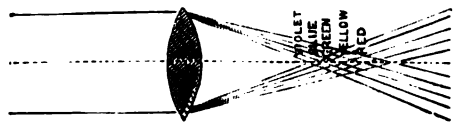
FIG. 5.—FOCI OF VARIOUS COLORED RAYS.

We have shown that a ray of white light entering a dense medium obliquely becomes decomposed at once, and we get a number of colored rays; but if the surfaces of this medium be parallel to each other the effect is not seen, as the one counteracts the other, and the rays dispersed by the one are re-combined by the other. It was also discovered that some kinds of glass possess great refractive but little dispersive power, while others, on the contrary, possess little refractive but great dispersive properties. If, therefore, we combine two lenses made from different varieties of glass, and possessing these opposing powers, we are able to send a ray of light through without splitting it up into its component colors. The two kinds of glass used for this purpose are *flint* glass, containing oxide of lead, and a light *crown* glass. The former is usually made into divergent and the latter into convergent lenses. A glance at Fig. 6 will show the effect of this combination. A ray of light R enters the prism, or portion of crown glass lens at *a*, and is at once decomposed, the red ray taking the direction *a r* and the violet the direction *a v*. On entering the flint glass lens or prism, the red ray takes the direction *r b*, and the violet the direction *v b*; they recombine at *b*, and the emergent ray R′ is colorless. In reality, however, it is necessary for photographic purposes to bring the yellow and indigo rays together, and for this purpose special kinds of crown and flint glass are used. With two lenses or prisms it is only possible to achromatize at most three colors, but if chosen with a suitable angle and material it is sufficient for all practical purposes. Figs. 7 to 12 show how these lenses are combined in different manners.

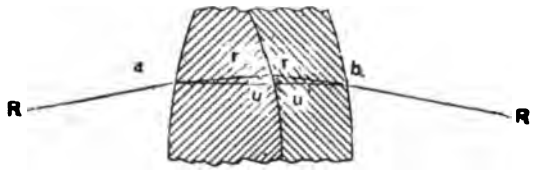

FIG. 6.—SEPARATION AND RECOMBINATION OF THE COLORED RAYS.

The first is a divergent meniscus, the second a plano-concave, the third a bi-concave, the

fourth a convergent-meniscus, the fifth a plano-convex, and the sixth a double convex lens. The first three are divergent and the others convergent lenses. They are each composed of the two kinds of glass, crown and flint (the convergent lens in each case being of crown and the divergent of flint glass), cemented together. They are termed achromatic, meaning literally "no color." As already stated, nearly all lenses now on the market are achromatic; even what are termed "single lenses" are in reality composed of two separate lenses of opposite characters cemented together, as shown in Fig. 3. See also **Astigmatism, Achromatism, Curvature of the Field,** and **Distortion**.

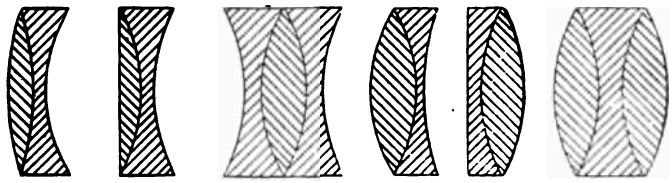

FIG. 7. FIG. 8. FIG. 9. FIG. 10. FIG. 11. FIG. 12.

VARIOUS FORMS OF LENSES.

ABSOLUTE ALCOHOL.—See **Alcohol.**

ABSOLUTE TEMPERATURE.—Temperatures taken from the absolute zero of temperature are termed absolute temperatures, and are measured from a zero point situated 458 deg. below the zero temperature on the Fahrenheit scale, and 273.7 deg. below the zero temperature on the Centigrade scale.

ABSORBENT.—A term used in chemistry to denote any substance possessing the power of absorbing gases or vapors into its pores, such as charcoal made from dense wood, which thus takes up ninety times its volume of ammoniacal gas.

ABSORBING BANDS.—Dark bands in the spectrum, which indicate the selective absorption of certain parts of the light. See **Spectrum.**

ABSORBTIMOMETER.—An instrument invented by Bunsen to determine the amount ot gas absorbed by a liquid.

ABSORPTION.—*In chemistry*, the taking up of a gas by a liquid, or by a porous solid. *In optics*, the retention of some rays, and the reflection of others, when they pass into an imperfectly transparent body. In the study of the proper light for the dark-room which will not affect the sensitive materials during manipulation, it is necessary to obtain media which will absorb the actinic rays and allow the non-actinic to pass through. Ruby glass was at one time supposed to be superior to anything else for this purpose, but unless of a very dark tint a little blue will also pass through. A yellow light is supposed to be superior to a red, as it gives greater illumination, although care must be taken that this does not allow too much green light to pass through it also. A study of the chemical effect of the spectrum will enable one to judge of the most suitable color. Full information upon this subject will be found under **Spectrum.**

ABSORPTION LINES.—Fine dark lines (Fraunhofer lines) observed in an absorption spectrum and caused by selective absorption by matter in an incandescent state. See **Spectrum.**

ABSORPTION OF HEAT.—The action performed by certain bodies—solids, liquids and gases—of absorbing radiant heat, their own temperature being thus raised.

ACCELERATOR.—A term applied in photography to certain agents which tend to hasten the action of the light upon the dry plate, or the working of the developer on the latent image. Heat will shorten the necessary exposure, as will also electricity, under certain conditions.

If the exposed dry plate previous to developing with ferrous oxalate be laid for a few minutes in a solution of hyposulphite of soda made in the proportion of 1 drachm of hypo to 150 ounces of water, the effect will be to considerably hasten the action of the developer. This method is largely adopted in Germany for the development of instantaneous or under-exposed negatives. Common salt, perchloride of mercury, and nitrate of chrysaniline also act as accelerating agents with the oxalate developer. With alkaline development, the alkali is the accelerator. If the temperature of the developer be raised its action will be considerably accelerated. Common salt will also act as an accelerator in developing bromide papers, bringing up the detail gradually and evenly before the shadows get too dense.

ACCESSORIES.—See **Portraiture** and **Studio.**

ACCIDENTAL COLOR. —Complementary colors seen when one looks at a white or light colored surface—after gazing fixedly on a bright colored object. If the object be red the accidental color is green; if blue, yellow, etc.

ACETATE OF AMYL.—See **Amyl Acetate.**

ACETATE OF COPPER.—See **Copper Acetate.**

ACETATE OF LEAD.—See **Lead Acetate.**

ACETATE OF SILVER.—See **Silver Acetate.**

ACETATE OF SODA.—See **Sodium Acetate.**

ACETATES.—The acetates used in photography are given in their various places, as referred to above. To test for acetates, mix with sulphuric acid and heat gently, when the smell of vinegar can be detected. A neutral solution of an acetate gives with ferric chloride a red liquid, which becomes turbid and deposits a brown precipitate on boiling.

ACETIC ACID (Formula, $C_2H_4O_2$).—Molecular weight, 60. Synonyms, *purified pyroligneous acid, methane carboxylic acid.* Methyl formic acid, formed by the acetous fermentation of alcohol. Acetic acid is a monotomic monobasic acid, and its salts are termed acetates.

Alcohol, when quite pure, is not affected by exposure to the air, but as soon as it is diluted and a portion of yeast added to it, the yeast soon acts as a ferment, and causes the spirit to unite with the oxygen of the atmosphere and become sour from the formation of acetic acid. A tray of finely-divided, spongy platinum is placed on a triangle over a porcelain dish containing a little alcohol, gently warmed, and the whole covered with a bell glass, standing on a wedge and opened at the top to allow a gentle current of atmosphere to pass through the apparatus. The oxidation of the alcohol proceeds very rapidly and acetic acid condenses in abundance on the inside of the jar. In this method of production, however, aldehyde is developed as an intermediate product. The addition of ferments greatly assists the oxidation of the alcohol. In France and Germany, wine is used; in England, malt vinegar is obtained in this manner, it being nothing more than acetic acid diluted and a little coloring matter added. Concentrated acetic acid may be obtained by neutralizing common vinegar with carbonate of soda, and crystallizing the acetate of soda thus formed. This acetate is then deprived of its water of crystallization, and fused at a gentle heat. After it is cooled, 82 parts of this salt are to be distilled with 98 of strong sulphuric acid, which removes the soda and liberates acetic acid. The acetic acid, being very volatile, distills over, and may be condensed.

Another method of preparation is by the destructive distillation of wood. Wood is heated in closed iron cylinders connected with condensers. In these receivers a watery liquid condenses, consisting of water, alcohol, acetic acid, acetone and other products. This liquid is re-distilled to remove some of the alcohol, and chalk is added to the residue. With this addition, the volatile acetic acid is conversed into non-volatile calcium acetate, which, on distillation to dryness, remains behind, the water and other volatile matters escaping. The impure calcium acetate is then gently heated to decompose the tar which it contains, and re-distilled with hydro-chloric acid, when crude acetic acid passes over and calcium sulphate remains behind. The density of the acetic acid thus obtained is about 1.06, and it can be purified by re-distillation and the addition of a small quantity of sodium carbonate or potassium dichromate. The wood usually employed in the preparation of acetic acid is known as coppice wood.

Glacial Acetic Acid is a term applied to the pure acid of sp. gr. 1.0635 at 64 deg. Fahr., because at ordinary temperature it becomes a crystalline solid. Pure acetic acid solidifies at or below 50 deg. Fahr. in colorless prismatic or tabular crystals, soluble in water, alcohol and ether. If heated above this temperature the crystals will melt, and it becomes a limpid liquid, with a sour pungent taste and odor. It blisters the skin, and acts as an acid poison. It boils at 118 deg. Fahr., and its vapor is inflammable.

Commercial Acetic Acid is generally described as being "glacial," or solid, at a certain temperature. The higher this temperature the stronger is the acid; therefore it is often diluted with water, and very often adulterated with sulphuric acid, added for the purpose of counteracting the effect of dilution by causing it to still retain its property of solidifying at a moderate temperature, and by this means deceive the purchaser of its true strength. The strength of commercial acetic acid can be approximately judged by its solidifying point. Place two or three drachms in a thin glass test tube, and lower it into powdered hypo to cool. A thermometer placed in the liquid will give the temperature, which should be read off directly the acid is seen to solidify, and compared with the following table.

Solidifying points of acetic acid of different strength :

Solidifying Point Fahr.	Per Cent. of Water.	Solidifying Point Fahr.	Per Cent. of Water.
62 deg.	0	50 deg.	5
60 "	.5	46 "	7
59 "	1	43 "	8
57 "	1.5	42 "	9
55 "	2	40 "	10
53 "	3	39 "	11
51 "	4	37 "	12

Another method is to find out the specific gravity of the sample at a temperature of 64 deg. Fahr. and compare with the following table:

Specific Gravity.	Percentage of Real Acid.	Specific Gravity.	Percentage of Real Acid.
1.002	2.0	1.031	22.0
1.004	3.0	1.032	23.0
1.005	4.0	1.033	24.0
1.007	5.0	1.034	25.0
1.008	6.0	1.035	26.0
1.010	7.0	1.036	27.0
1.012	8.0	1.038	28.0
1.013	9 0	1.039	29.0
1.015	10.0	1.040	30.0
1.016	11.0	1.041	31.0
1 017	12.0	1.042	32.0
1.018	13.0	1.044	33.0
1.020	14.0	1.051	40.0
1.022	15.0	1 061	50.0
1.023	16.0	1.067	60.0
1.024	17.0	1.070	70.0
1.025	18.0	1.0735	80.0
1.026	19.0	1.073	90.0
1.027	20.0	1.0635	100.0
1.029	21.0		

A curious fact that should be noted is that the liquid containing 100 per cent. of acetic acid has the same specific gravity as one containing between 50 and 60 per cent.

It often happens that a trace of sulphuric acid used in its manufacture is unintentionally left in it, and the presence of either sulphuric or hydrochloric acid is fatal to photographic processes, for the reason that they quickly precipitate nitrate of silver. This fact enables one to readily detect the presence of either in the following manner: Dissolve a small crystal of nitrate of silver in half a drachm of water, and then add another half a drachm of the glacial acetic acid to be tested, and if this mixture remains quite clear when exposed for a little time to the light, the acid can be used with safety. If, on the other hand, there is either hydrochloric or sulphuric acid present, a white deposit of chloride or sulphide of silver is quickly formed, and if aldehyde or any other volatile matter be present, the mixture will soon discolor if exposed to the action of daylight. If we have the white deposit only, and we are desirous of finding out whether it be hydrochloric or sulphuric acid that is present, it is easily done by the addition of nitric acid, which rapidly dissolves the sulphite, but leaves the chloride unchanged.

Another form of acetic acid is sold in England under the name of *Beaufoy's Acid.* It contains 30 per cent. of real acid, so that in making up formulas it is necessary to treble the quantity, in order to get the correct amount of acetic acid. It should also be tested for impurities, as it usually contains many.

Acetic acid is sold in this country as "Acetic Acid No. 8." This is usually glacial acetic acid diluted with eight times its volume of water.

Acetic acid is miscible in all proportions with water and is employed in photography as a solvent for gelatine in aceto-gelatine emulsions, and as a restrainer in acid development forming silver acetate with the depositing silver.

ACETIC ETHER [Formula $(C_2H_3O_2)C_2H_5$].—A compound of acetic acid and ether. It has an agreeable odor of apples, and is easily manufactured artificially by distilling a mixture of alcohol, oil of vitriol, and acetate of potash.

ACETOMETER (*synonym*, acetimeter).—A hydrometer graduated for determining the strength of commercial acetic acid, according to its density. It is not always possible to ascertain correctly the amount of water present by the specific gravity, for an acid that contains 21 per cent. of water has a higher specific gravity than either a stronger or a weaker sample.

ACETYLENE (Formula C_2H_2).—An illuminating gas obtained from calcium carbide when brought into contact with water. The acetylene is evolved in accordance with the following equation:

CaC_2	+	H_2O	=	C_2H_2	+	CaO
Calcium Carbide	added to	Water	forms	Acetylene	and	Quick Lime.

With this reaction great heat is evolved and the gas is often beyond the control of the experimentalist. The following arrangement has been devised by Mr. F. B. Grundy:*

* *Photography*, August 8, 1895.

In the diagram (Fig. 13), A is a forty ounce flask containing the calcium carbide broken up into small pieces, the quantity of carbide placed in the flask being dependent, of course, upon the quantity of gas required. It is to be borne in mind that from each pound of calcium carbide about five cubic feet of acetylene will be given off. B is a glass vessel, known to chemists as a separating funnel, fitted with a stopcock, by means of which the water contained in the vessel can be allowed to drop on the carbide in the flask. The acetylene which is produced is led off from the generator by means of the tube C into the two-necked bottle D containing water. This is to wash the gas, and also to prevent the steam which is formed from condensing in the pipes, and thus obstruct the free passage of the acetylene, which passes by the outlet tube E to the gasholder, in which it is to be stored.

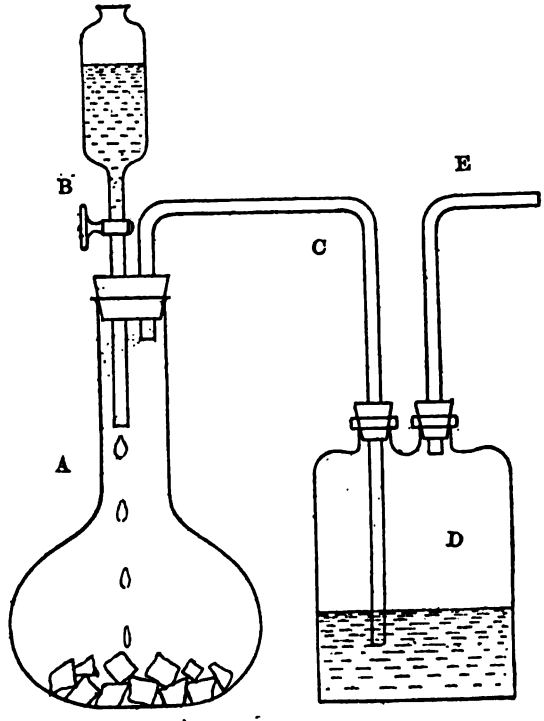

FIG. 13.—GRUNDY'S APPARATUS FOR THE PRODUCTION OF ACETYLENE.

Acetylene was discovered by Berthelot about 1845, but little was known about it owing to the expense of production. The recent discovery of S. L. Wilson and Prof. V. B. Lewes has enabled us to produce it from calcium carbide at a very small cost. Some experiments made by Professor Lewes show that its actinic power, compared with ordinary coal gas, was about 2.5 times as great. This property will render it a valuable illuminant for photographic purposes. The flame is so intense that small flat burners have to be employed. The light emitted has a remarkable actinicity.

Acetylene is soluble in water, alcohol, and most other liquids. It can be condensed by pressure into a liquid. When diluted with twelve times its volume of air it is highly explosive, but this property is lost when the dilution exceeds twenty parts. It forms dangerously explosive compounds with gold, silver, copper, mercury, and several other metals.*

ACHROMATIC.—A term applied in photography to a lens which has been corrected for chromatic aberration, or, in other words, when its visual and chemical foci are united. (See *Chromatic Aberration* under **Aberration**, and **Achromatism.**) This effect is produced by combining two lenses of different dispersive power, the one being of flint glass and the other of crown glass. A lens is said to be achromatic when it deflects rays of white light without coloring them. For a method of testing a lens for achromatism, see **Chemical Focus.**

ACHROMATISM.—The destruction of the colored fringes which accompany the image of an object seen through a prism or lens. The principles upon which achromatism is effected may be briefly explained as follows: Prisms comprised of different substances do not give spectra occupying the same relative lengths; hence, it follows that the primary colored rays in passing through different substances are not refracted in the same relative proportions, and the angle formed by two rays—the red and the violet, for instance—is greater when the light is refracted by some substances than it is when refracted by others. The angle formed between the extreme rays of the spectrum measures the *dispersion* of the rays, and it is found that the dispersive power of flint glass is to that of crown glass in the ratio of 3 to 2, so that if a prism of flint glass gives a spectrum three inches long, a similar prism of crown glass will give a spectrum of only two inches. It is possible, therefore, to arrange two prisms, the one behind the other, so that the chromatic effect of the first may be neutralized by that of the other so as to destroy the color and still retain a certain amount of refraction. It is impossible, however, to obtain *perfect* achromatism, there being always a residual spectrum.

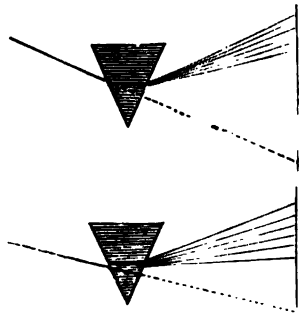
FIG. 14.—DIFFERENT DISPERSIVE ACTIONS OF CROWN AND FLINT GLASS PRISMS.

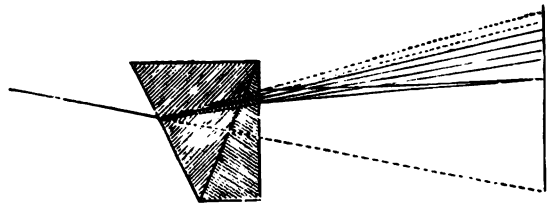
FIG. 15.—COMBINATION OF TWO PRISMS TO OBTAIN ACHROMATISM.

Fig. 14 shows (exaggerated) the action of two prisms—one possessing great refractive but little dispersive power, while the other has great

* T. C Bolas, in THE PHOTOGRAPHIC TIMES.

dispersive but low refractive properties; and Fig. 15 explains how these two, when united, counteract each other to obtain achromatism.*

The merit of this discovery of achromatic compensation belongs to John Dollond, who arrived at it by skillful and systematic experiments. Upon its principle all achromatic lenses are constructed. For a method of testing for achromatism, see **Chemical Focus.**

ACRHOMATOUS.—Achromous, Achroous—without color.

ACID.—A salt of hydrogen in which the hydrogen can be replaced by a metal, or can, with a basic metallic oxide, form a salt of that metal and water. Acid oxides of the same element are distinguished by the terminations of *ous* and *ic*, as sulphurous and sulphuric, the latter containing the most oxygen. They are also called anhydrides. They unite with water and form acids, having the same terminations. By replacing the hydrogen by a metal they form salts distinguished by the terminations *ite* and *ate* respectively. These acids are called oxygen acids; formerly it was thought that all acids contained oxygen, this element being regarded as the acidifying principle (generating acid). But many acids are formed by direct union of hydrogen with an element, as hydrochloric acid (HCl), hydrosulphuric acid (H_2S), or with an organic radical, as hydrocyanic acid. Acids that are soluble in water will cause blue litmus paper to redden and have a sour taste. Acids are said to be monobasic, dibasic, tribasic, etc., according as one, two, or three atoms of hydrogen can be replaced by a metal. Organic acids can be produced by the oxidation of an alcohol or aldehyde. They contain the monad radical (HO.OC) once if they are monobasic, twice if dibasic, thrice if tribasic, etc. They are also classed as monotomic, diatomic, according as they are derived from monotomic or diatomic alcohol. Acids derived from diatomic alcohol can be alcohol acids or aldehyde acids. Many organic acids occur in the juice of vegetables and in animals. An acid and a base will rarely exist together, but will combine to form the corresponding salt.

In adding citric acid to the alkaline developer, it acts not only as a restrainer, but it also combines with some of the free alkali, lessening the amount in the developer.

ACID SULPHITE.—Prepared by adding an acid to sodium sulphite, preferably tartaric acid. This substance has been strongly recommended by A. Lainer† and others as an addition to the fixing bath. The advantages are said to be that the solution thus fixes and clears at the same time. The bath also keeps perfectly. See **Acid Fixing Bath.** Acid sulphite is sold commercially as a lye. In this state it is a pale, yellowish liquid, and it is only necessary to add 2 ounces of this to a quart of hypo fixing solution.‡

ACID FIXING BATH.—The question as to whether the acid fixing bath should be acid. alkaline or neutral is still an undecided one. Eder was the first to advise the addition of sulphite of soda to the hyposulphite solution; others preferred carbonate of soda and bisulphite. Dr. Higginson, after a series of experiments, concluded that the pure hyposulphite bath was the best, as it acts more promptly, with more certainty, is the least costly, and simplest to make.

The acid bath has, however, the property of removing all yellow discoloration and of giving a clear, transparent negative, and of stopping the action of the alkaline developer left in the film. Long immersion in the bath tends to weaken the image, however, and for this reason some workers prefer to fix first in an ordinary bath and finally in an acid one. Whenever acid is added direct to the hypo bath, sulphur is separated, the solution is turned milky, and the negatives rendered opalescent.

Professor Lainer discovered that if a solution of sodium sulphite (with citric or tartaric acid) be added to the hypo bath, a slight discharge of sulphurous acid takes place, after which the solution remains clear.

The following formula was afterward recommended:

LAINER'S ACID FIXING BATH.

Hypo solution	1 litre.
Acid bisulphite soda lye	50 c.cm.

The latter is a commercial article.

EDER'S ACID FIXING BATH.

Hypo, 1 to 5	1 quart.
Tartaric acid, 1 to 2	6 drachms.
Sodium sulphite, 1 to 4	2½ ounces.

Mix the last two solutions and add to hypo.

ACIDIMETER (*synonym*, acidometer).—An instrument for measuring the strengths of acids.

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* From Burton's "Photographic Optics."

† *Photo Correspondenzen.*

‡ W. J. Harrison in "Chemistry of Photography."

ACIDIMETRY.—The process of determining the quantity of real acid in a sample of hydrated acid. This is accomplished by volumetric or by weight analysis. The former method is carried out by ascertaining the measured quantity of a standard alkaline solution required to saturate a given quantity of the acid. By weight analysis a known weight is decomposed with an excess of acid, carbonate of sodium or potassium, and estimate by weight the quantity of carbonic anhydride evolved. When this is done the quantity of acid can easily be ascertained.

ACLASTIC.—Not possessing the power of refracting light.

ACROMETER.—A hydrometer graduated for testing the specific gravity of oils. An oleometer.

ACME PAPER.—A trade term given to a method of gelatino-chloride printing, which differs from the ordinary process in the fact that, instead of the chloride of silver being formed in the emulsion and this spread upon the paper, the latter is coated with the gelatine containing the chlorides only. This is then floated on a silver bath, and the chloride of silver thus formed in the same way as with albumenized paper. The sensitizing bath is made up of 1 part of silver nitrate dissolved in 9 parts of water and neutralized, or

Silver nitrate	50 grains.
Ammonium nitrate	30 grains.
Water	1 ounce.
Liq. ammonia (.880)	3 minims.

When dry it can, if desired, be fumed with ammonia vapors. The toning baths recommended are:

For Purple Tones.

Borax	6 drachms.
Water	2 pints.
Gold chloride	6 grains.

For Black Tones.

Ammonium sulphocyanate	6 drachms.
Water	2 pints.
Gold chloride	6 grains.

The treatment of the sensitized paper is the same as described in the gelatino-chloride process.

ACTINIC.—A ray of light usually possesses three properties, the luminous, the calorific, and the actinic. The actinic is that peculiar property which produces the chemical changes upon which the whole art of photography is based. A ray of white light may be split up into its constituent colors, giving what is termed the solar spectrum. We find that actinism, or the property of producing chemical changes, exists chiefly among the blue and violet rays, while the yellow are termed non-actinic. The violet rays produce the chemical action, but the yellow or luminous rays produce the visible image on the screen. Chromatic aberration in a lens tends to divide these two, so that it can be seen how important it is to have the two foci combined. For further information on this subject see **Aberration.**

ACTINIC FOCUS.—See **Focus.**

ACTINICISM.—The chemical action of sunlight. See **Actinic.**

ACTINOGRAPH.—An instrument invented by Mr. Hunt for regulating the variations of chemical influence on the solar rays; fully described in the British Association Reports for 1845-46.

The name has also been given to a more recent invention of Messrs. Hurter and Driffield for calculating photographic exposures. It consists of a small box, which can be easily carried in the pocket, and contains four suitably mounted logarithmic scales which correspond with the light, the lens, the speed of the plate, and the exposure. See **Actinometer.**

ACTINOLOGY.—The science of photo-chemistry.

ACTINOMETER.—There are various forms of actinometers, which may briefly be termed instruments for measuring the actinicity of light. In photography, they are used in conjunction with certain logarithmic tables to endeavor to work out the necessary exposure to be given to the dry-plate. They may also be used for timing positive prints, especially those in which the image is invisible, such as in the carbon or asphalt process. The terms actinograph, photometer, and other fancy names have also been given to them. A description of the most notable kinds will be given.

Herschel's Actinometer.—An instrument devised by Sir John Herschel for measuring the intensity of the solar rays. It consists of a thermometer with a large bulb, filled with a dark

blue fluid, and enclosed in a box, the sides of which are blackened and which is covered with glass. It is placed for a minute in the shade, then a minute in the sun, and then one more minute in the shade. The mean of the two variations in the shade is then subtracted from that in the sun, and the result measures the influence due to the solar rays.

Draper's Actinometer, invented by Mr. H. Draper, of New York, is based upon the fact that ferric oxalate, when exposed to the action of the light, gives out carbonic acid. This is explained by the following:

Ferric Oxalate		Ferrous oxalate		Carbonic anhydride.
$Fe_23C_2O_4$	=	FeC_2O_4	+	$2CO_2$

The action of the light vibrations upon the ferric oxalate molecules is to split them up, and for each molecule so acted upon one molecule of carbonic anhydride is liberated. Draper's apparatus consists of a small glass cistern, containing exactly 500 grains of a standard solution of ferric oxalate. The cistern is covered over with an opaque covering, except one square inch through which the light is admitted. After the exposure to the light, the amount of carbonic anhydride disengaged was calculated by the difference in weight before and after the exposure.

Roscoe's Actinometer.—In this the actincity of daylight or sunlight is measured by the exposure of sensitive silver chloride paper to its action for certain lengths of time at each hour. To effect this the piece of sensitized paper is fixed round a drum. This drum can turn on a horizontal axis, and the frame which supports it can slide horizontally. A piece of thin sheet brass is fixed over the drum, and a hole is cut through it. It is so arranged that it presses down lightly on the top of the drum; thus a small piece of the sensitized paper is always exposed to the daylight, and the rest in total darkness. Thus, by the horizontal movement of the frame and the turning of the drum, every part of the sensitized paper will have been brought under the hole. The manner in which it works is this: The frame which supports the drum is continually moving slowly in a horizontal direction. Between the hours the drum does not turn, but only moves slightly in a horizontal direction. At the hour the drum turns suddenly for a small part of a revolution, thus exposing a fresh piece of paper under the hole. After two seconds it again turns suddenly as before, exposing that piece of paper for two seconds. In a similar manner fresh pieces of paper are exposed for 2, 4, 6, 10, 20, 40, 90 seconds, and after this the drum does not rotate again till the next hour, when a similar set of movements takes place. Hence, between the hours, there is a piece of paper exposed for 57 minutes, and which is useless on account of the long exposure. Owing to the horizontal movement of the drum, a fresh piece of paper is exposed when one complete revolution of the drum has taken place. An instrument of this kind is set up at South Kensington, and Captain Abney has designed a special reading-off apparatus which greatly facilitates the operations necessary for the daily readings.

Woodbury's Photometer is perhaps the simplest constructed instrument of this kind. It was invented by the late W. B. Woodbury, and consists of a small, circular box having something of the appearance of a watch. A slip of paper passes under a hole in the centre of a disk printed with a scale of tints. The portion of the sensitized paper visible through the centre aperture being exposed to the light for one minute, it is carefully compared with one of the surrounding tints, whichever tint it corresponds with; knowing the value of that tint, the necessary exposure is easily arrived at. If a bromide plate is used, bromide paper sensitized with a 10 per cent. solution of potassium nitrate must be placed in the photometer; for a chloride plate chloride paper, and suitable tints, to be used as guides, prepared. This little instrument is also extensively used as a guide to the exposure of printing frames when making prints upon a carbon tissue, or by other processes where the action of the light is invisible. For illustration of Woodbury's Photometer, see **Carbon Process.**

Stanley's Actinometer is a similar arrangement, and consists of a ribbon of sensitive paper placed upon a reel, so that a small portion may be drawn out at a time under a glass cover, upon the under side of which is placed a piece of tinted paper. By taking the time required for the sensitive paper to arrive at the standard tint, the relative actinicity of the light is ascertained.

Decoudin's Photometer is an instrument for determining the necessary exposure by the apparent brightness of a portion of the image as seen on the ground glass. This is done by rotating a diaphragm pierced with various-sized holes, the point at which the illumination of a figure is just extinguished being marked with a letter which, on reference to a table, gives the necessary exposure.

Warnerke's Photometer.—In this, phosphorescent paint is used. The light from the subject is allowed to fall upon it for one second. The paint then becomes luminous, and its brilliancy is estimated by viewing it through translucent screens varying in thickness.

Ballard's Actinometer is also based upon the absorption and luminous powers of phosphorescent paint Wall thus describes it.*

**Amateur Photographer*, 1892.

"It consists of a square tube of wood having at one end a hinged cover, with, on the inside, a prepared surface and a spot in the centre. The method of using is to open the cover and look through the tube directly at the object to be photographed for half a minute, then closing the tube, a central blue spot will be seen which will gradually disappear. The number of seconds which it takes to do this, forms the basis of the calculation of a series of tables which accompany the actinometer." Both this arrangement and Warnerke's are unreliable, owing to the fact that the light emitted from the luminous paint is not constant; further, heat has a marked effect upon the brilliancy.

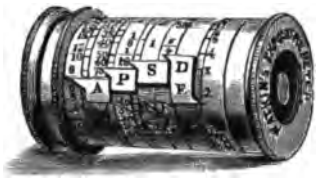


FIG. 16—WATKINS' EXPOSURE METER.

Watkins Exposure Meter.—As will be seen in the accompanying diagram (Fig. 16), this little instrument consists of a brass cylinder with movable pointers and scales. At one end is a strip of bromide paper which is exposed to the light falling on the subject to be photographed. At the same time the other end of the cylinder is unfastened, and being on the end of a chain, is set swinging, each swing representing half a second. The number of seconds it requires to darken the bromide paper to the depth indicated is thus calculated; one of the pointers is set to that number, and the other to the various factors, such as quality of subject (according to table), diaphragm and speed of plate. This done, the pointer E will indicate the exposure required.

Leutner's Photometer.—The invention of Aug. Leutner, of Vienna. It consists of a metal basis firmly screwed to the printing frame. To this is fastened a small strip of felt, which presses the sensitive paper firmly against the scale. This scale consists of ten degrees produced by a photo chemical process on yellow plate glass. A movable indicator serves as an indicator of the scale we require to copy to. The change of the sensitive paper can be viewed from outside, and when it arrives at the tint corresponding to the density of the paper, we know that the exposure is about enough. See Fig. 17.

FIG. 17—LEUTNER'S PHOTOMETER.

The word sensitometer is often used to denote instruments of the kind described, but this is erroneous. Sensitometers will be found under their own heading, and differ from actinometers insomuch as an actinometer is an instrument to measure the actinicity of light upon certain photographic preparations, and a sensitometer is an instrument arranged to measure the sensitiveness of such preparations to the actinic rays. See also **Exposure Meters.**

ACTINOMETRIC.—Pertaining to an actinometer. Under this heading we will give the most interesting results that have (according to Professor Roscoe) been obtained by actinometers for measuring the chemical action of the solar rays. The diagrams of curves on the next page (Fig. 18) show the variation of the chemical action of daylight with the different months. Each curve is marked with the month, and denotes the rise and fall of the chemical intensity from 6 A.M. to 6 P.M. With this chart it will be seen that at mid-day in July the chemical intensity is more than seven times greater than at mid-day in December. This chart was made at Kew, but it is a well-known fact that this chemical action of light varies to a very considerable extent in different portions of the globe. According to the various observations of photographic travelers we find that the nearer the equator the more difficult it is to obtain good photographs; also the exposure in the tropics with the blazing sun is required to be much longer than on a gloomy day in England. Careful scientific observations have proved that the chemically active rays of the tropics are much greater than in this country. At Pará, situated nearly under the equator, they were, according to observations made on a certain day by Professor Thorpe, seven times greater than on the same day at Kew; therefore, if the statement of increased exposure be correct, we have to look for some other cause than the diminution of the sun's chemical intensity.

ADAMANTINE PROCESS.—A name given to a process of half-tone etching on copper, invented by Mr. A. C. Austin. The process is a secret one, and termed adamantine on account of the hardness of the surface. All that we can find published of this process* is that the negatives are produced nearly as for the zinc method, but the printing and etching are entirely different. The plates are coated quickly, printed in four or five minutes, developed in cold water (without any previous "rolling up" and without any "rubbing") and give a beautiful black

* From *Wilson's Photographic Magazine.*

image, when, after mixing and drying, the plate is ready for the proof-maker without removing the coating.

ADAPTER.—This term is applied to an arrangement fitting to a studio camera, by means of which plates of smaller dimensions than the camera is intended for can be used. Fig. 19 shows an adjuster with hinged ground-glass and plate-holder inserted. A removable attachment to a camera, enabling the operator to work a plate of larger dimensions than that for which his camera is constructed.

ADIACTINIC.—See **Diactinic.**

ADIAPHOROUS.—A term sometimes applied in chemistry to substances which are neutral, *i.e.*, neither acid or alkaline.

ADMISSION, CENTRE OF.—See **Optics.**

AERIAL IMAGE.—A properly corrected lens if directed to an object will form at its focus an aerial image of that object, each portion of it being at the same relative distance from any other part as in the original object itself.

AERIAL PERSPECTIVE.—A term used by artists to denote that high artistic management of the perspective of a landscape which not only presents the objects of the relative size that they must, according to the rules of perspective, appear to the eye when viewed from the observer's standpoint, but also imparts effects as if they were seen with their outline softened and the idea of distance rendered clearly. The same effect may be obtained in photographing landscapes, and for the purpose usually long focus lenses or large diaphragms are required. It will sometimes occur that the atmosphere reflects so much blue light that the distant parts of the view are entirely or nearly lost. The use of orthochromatic plates, or the interposition of a yellow screen, will remedy this defect. At the same time, it must not be overdone, as it is easy to make the distant background appear too close and sharply defined, thus losing all idea of aerial perspective.

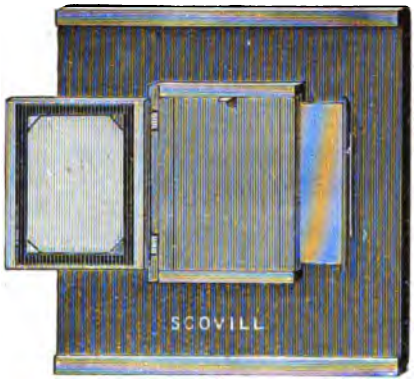
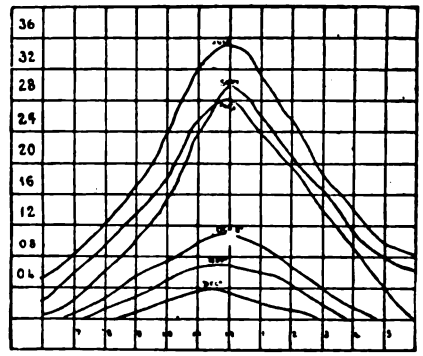


FIG. 19.—CAMERA ADAPTER.



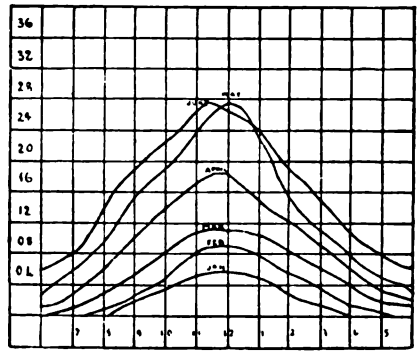


FIG. 18—CURVES OF CHEMICAL INTENSITY OF LIGHT DURING VARIOUS MONTHS.

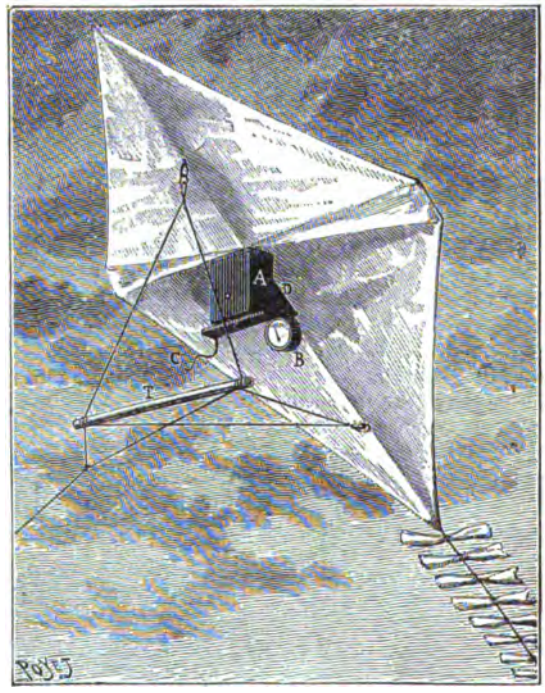


FIG. 20.—KITE CAMERA.

AERIAL PHOTOGRAPHY.—In the year 1858 Nadar, of Paris, made photographs from the car of a balloon. A balloon camera for obtaining photographs from a great height was invented and patented by Woodbury in 1877. To a captive balloon was suspended a camera, fitted with a rapid lens and an instantaneous shutter. Inside the camera were two rollers carrying a band of sensitive tissue moved by clockwork. This clockwork and the instantaneous shutter were both controlled by an electro-magnet communicating with the operator on *terra firma* by electric wires running inside the cord to which the balloon was attached. By means of a small battery the operator below sends a current of electricity through the wire to the electro magnets. The actions of the latter are first, to release the clockwork and bring into position a piece of sensitive tissue or film, and, secondly, to release the shutter and make the exposure. This operation is repeated until the whole

of the sensitized tissue contained in the camera is exhausted, when the balloon is drawn to the earth and the images upon the exposed tissue developed. The uses of an instrument of this kind are many. For war purposes it would be invaluable, enabling one to photograph and ascertain with certainty the position, strength, and movements of the enemy. For exploring expeditions, the advantages to be reaped by the use of such an instrument cannot be over-estimated.

FIG. 21.—PHOTOGRAPH MADE WITH A KITE CAMERA.

For similar purposes, M. Batut, a clever French amateur, has invented a kite camera, the following description of which was given in the *Photographic Times:* "The kite is diamond-shaped, with a long tail, assuring stability when it has ascended into the regions of the clouds. The cord holding it to the earth is attached to the frame by a sort of trapeze, so arranged that the camera *A* (see Fig. 20), which is also fastened to the frame by the triangular support *D*, shall have an unobstructed range of whatever is below. The shutter, which is of the "drop" variety, working horizontally, being actuated by two rubber bands, is liberated by the burning of a fuse, *C*, which burns through a thread holding the shutter on tension; the thread being burned releases the shutter, which, in its flight across the opening of the lens, also liberates a scrap of paper which, floating down, shows the manipulator that the exposure has taken place. A self-registering barometer, *B*, is attached, to show the altitude attained. The cut (Fig. 21) shows a result obtained by M. Batut, at an altitude of 127 metres, on February 13, 1889, at 11 A.M. It represents a plan view of a farm-house, with its outbuildings. The kite employed is about 7½ feet in height; the camera weighed 1,200 grams.

Another curious form of aërial photographic apparatus was developed by a French inventor, M. Denesse. It consists of a photographic camera attached to a rocket. An umbrella-like parachute is also fixed to the rocket-stick. When fired into the air this is closed, but as soon as the rocket begins to descend it opens out, and the whole returns gracefully to the earth. In this the camera is cylindrical in form, and has round its circumference twelve lenses—a sensitive plate is in the centre. The lenses are provided with a shutter which opens and closes instantly on the camera commencing to descend. It is then drawn back to the operator by a cord attached before the firing of the rocket. The principal advantages of this form of apparatus are cheapness of operating and freedom from risk.

FIG. 22.—BALLOON PHOTOGRAPH FROM A HEIGHT OF 2,500 FEET.

Many other methods of making photographs from a height have been devised and some very useful results obtained. It is not only for war and exploring purposes that here pictures become valuable: students of geodesy will also find them of service in the construction of plans and maps. Dr. Frank Stolze says that it may be confidently assumed that during the exposure the sensitive plate on which the photograph is made has hardly ever been horizontal enough to allow the plate to be considered analogous to a parallel projection of the natural landscape; it is much more likely to be always more or

less perspectively foreshortened There exists, however, a particularly simple and reliable means of finding proper geometrical projections from the perspective projection. This is done after the following manner: An exact square of large dimensions—say 600 feet—is described upon a flat part of the ground to be photographed, and the four corners marked distinctly, so that they shall be plainly seen in the photograph. From the now perspectively foreshortened image of the square we can find with ease all the constituents of perspective distortion, so that it is possible by working out the perspective backward to find for every point of the picture the corresponding point of the geometric construction, which is then, when we have to deal with level ground, a comparatively easy matter. But when, however, the ground is hilly and undulating, the matter becomes a more difficult and complicated one. It is then necessary to take as auxiliaries some ordinary photogrammetric views in order to find out the difference of levels, and to reduce all the data on the photograph to the same horizontal. Notwithstanding this, however, the work will be far easier than when one has to trust to terrestrial photogrammetry; and it may, indeed, be stated that views taken from a height and used in this manner far exceed in simplicity and ease all that has yet been done in the way of special views taken for purposes of geodesy. In fact, views taken from balloons, parachutes, kites, or rockets, are undoubtedly the geodesic views of the future.

AETHER.—See **Ether.**

AFFINITY.—Chemical affinity or chemical attraction is the force by which the union takes place of two or more elements to form a chemical compound. According to another definition, it is a force exerted between two or more bodies at an infinitely minute distance apart, by which they give rise to a new substance having different properties to those of its component parts. Elements have the greatest affinity for other elements which differ most in their chemical properties. Thus, hydrogen has a great affinity for chlorine and oxygen, but the affinity between chlorine and oxygen is much weaker. Acids unite readily with alkalies and most metals with sulphur. When two salts are mixed together they are decomposed if an insoluble substance can be formed. Thus, $AgNO_3$ (silver nitrate) + NaCl (sodium chloride) yields $NaNO_3$ (sodium nitrate), and insoluble AgCl (silver chloride) and $BaCl_2$ (barium chloride) + $MgSO_4$ (magnesium sulphate) yields $MgCl_2$ (magnesium chloride) and insoluble $BaSO_4$ (barium sulphate), as H_2SO_4 (sulphuric acid) expels HCl (hydrochloric acid) or CO_2 (carbonic acid), but when two salts are fused and a more volatile compound is formed, it is driven off, as when NH_4Cl (ammonium chloride) is heated with dry $CaCO_3$ (calcium carbonate) then $NH_4)_2CO_3$ (ammonium carbonate) volatizes. The relative affinity between different substances varies with their temperature, insolubility, and power of vaporization. Alteration of the temperature alters the affinity. Thus, if mercury be heated to its boiling point it absorbs oxygen, which it liberates at a still higher temperature.

The investigation of the relative proportions in which bodies combine forms the basis of the atomic theory or doctrine of chemical equivalents.

Affinity of Solution is such an affinity as exists between a soluble salt and its fluid in which it is dissolved. Until the liquid is saturated with the salt the two can combine in an indefinite ratio, instead of being limited to the fixed proportions, in which alone chemical affinity operates. See **Chemistry.**

AGAR-AGAR (Bengal Isinglass).—A vegetable gelatine obtained in China from species of sea-weeds (*Fucus spinosus* or *Gelidium corneum*). Transparent colorless strips, almost completely soluble in water. If melted down and allowed to set it forms a thick, tasteless and odorless jelly. It is sometimes used for photographic purposes in place of gelatine, but possesses no advantages over that substance.

AGENT.—That which possesses the power of acting or producing effects upon anything else. In photographing, light is the agent which forms the invisible image upon the sensitive emulsion plate; the developer is the agent which causes this mage to become visible, and sodium hyposulphite is the agent which fixes or makes more permanent the same.

AIR.—A knowledge of air and its various properties should be useful to the photographer, as it forms an important item in his operations. It deceives him in outdoor work, and is a silent destructive agent to his chemicals and appliances. The greatest point to observe, is the supply of fresh air to the dark-room, or other places in which photographic operations take place. This subject is, however, fully treated upon under **Ventilation,** *q.v.*

The air we live in is a mixture of several different kinds of gaseous substances. Oxygen and nitrogen, however, are its chief constituents, the others being present in minute quantities. Roughly speaking, dry air contains in ten thousand parts (by volume) 7,912 of nitrogen, 2,080 of oxygen, 4 of carbonic acid, and 4 parts of carburetted hydrogen, also a trace of ammonia. We cannot see the air in its pure state, although it can be weighed, compressed, or made to expand.* The weight of air is about 760 times lighter, bulk for bulk, than water. The actual thickness of

* Recent experiments made by Professor Dewar, at a very low temperature, have enabled him to liquefy air.

the layer of atmosphere surrounding the globe is not correctly known. Wollaston assigned a limit of forty to forty-five miles, but from observations made by M. Lilias at Rio Janeiro on the twilight arc, he infers that the extreme limit is between 198 and 212 miles, a very considerable difference. Unfortunately, it is not possible for a man to ascend to any great height, for at eight miles all animal life would be destroyed. The highest ascent that has been made by persons who have returned alive was that made by Mr. Glaisher and Mr. Coxwell. They ascended to an altitude of 37,000 feet, or a fraction over seven miles, and but for the ability of one of the occupants of the car to open the escape valve (which he did by catching the cord between his teeth, his hands being useless), they would neither have survived many minutes.

The pressure of the atmosphere upon the earth is about 15 pounds to the square inch, which is technically termed one atmosphere. When large surfaces are concerned this increases to an astonishing degree, the pressure of the atmosphere upon a square mile being 263,000,000 tons.

Besides the substances already mentioned the air contains an amount of aqueous vapor which varies with the temperature, and is more abundant with a south and west wind in summer and in warm weather than with a north and east wind in winter and cold weather. This vapor rises from water in minute molecules, which float freely about in the interspaces between the atoms of the oxygen and nitrogen. And here we will mention a fact that it is essential for photographers to remember. If we bring into a warm room a glass containing cold water, the aqueous vapor condenses and becomes visible on the surface of the glass. If a cold lens is brought into the room the same effect takes place, and, if not noticed, the result of using it would be a hazy picture. In such cases it would be of no use to wipe away this moisture, but to lay the lens in a warm part of the room for a few minutes. This condensation of moisture can be made useful by the photographer. For instance, in photographing silver goblets, or vessels of any kind, the bright reflections will prevent a satisfactory result from being made. If, however, the vessel be filled with ice-water, the condensation on the exterior will soften the reflections and make a more harmonious picture possible.

Combustion and respiration act similarly in vitiating the air by consuming the oxygen and giving back carbonic acid and water. Carbonic acid and water are both considerably heavier than air, and it would be inferred that they would sink to the floor, but when liberated they are warm, and consequently ascend, being in this state lighter than air. The foul air, therefore, accumulates at the top of the room, and for this reason chemicals (unless in closely stoppered bottles) and sensitive materials, such as plates and paper, should never be stored higher than about five or six feet from the floor.

Many of the chemicals and solutions used in photography absorb the oxygen from the air. The pyrogallic, ferrous-oxalate, and most other developers absorb oxygen, and for this reason will not keep. The best plan to protect oxidizable aqueous solutions from the air is to cover with a layer of about half an inch of oil. The liquid can be drawn off with a glass tube bent to form a syphon. See **Oxidation.**

There are also many substances which take up water from the air, drying it, by becoming liquid themselves. Among these may be named calcium chloride and potassium carbonate. This property is utilized in many cases in which it is required to preserve any substance from being spoilt by the aqueous vapor. Platinum paper, for instance, has to be kept perfectly dry, and for this purpose calcium chloride is used.

Since the above was written the discovery has been made by Lord Raleigh and Professor Ramsay of the existence of another element in our atmosphere. They noticed that the nitrogen extracted from the atmosphere had not the same density as that obtained from such substances as nitric acid or ammonia. This led to a close investigation and the discovery of a new gas to which the name Argon was given. It is two and a half times as soluble as nitrogen and nearly as soluble as oxygen. Its spectrum differs from all other known gases.

Some very interesting experiments have been made at low temperatures. Professor Dewar discovered that nearly all solid bodies at the temperature of —200 deg. C, if exposed to the light and then viewed in the dark, appeared phosphorescent. At this temperature all chemical action ceased and chloride of silver remained unaltered by the light. Another important discovery was that, notwithstanding these facts, a photographic dry-plate could still be made to receive a latent image although the speed of the emulsion was considerably reduced. Captain Abney estimates, taking the speed of a plate, under ordinary circumstances, at 100, it was reduced to 25 at a temperature of boiling air, from which he inferred that if it were possible to arrive at the absolute zero (—273 deg. C.) the molecules of bromide of silver would not be acted upon at all, and no latent image could be impressed upon the plate.

AIR-BELLS.—Small bubbles of air which frequently make their appearance in photographic operations; for instance, in coating glass with emulsion or paper with albumen. They can usually be removed by pricking with a needle, which for convenience is fixed in a handle of wood. On immersing a plate in the developer air-bells often adhere to the film, and in consequence development does not take place at those parts, and they appear as transparent spots in the fixed negative. To prevent this the exposed plate is sometimes placed for a few seconds under a running tap previous to development, or the air-bells may be removed by a broad camel-hair

brush immediately after the plate is immersed in the developing solution. Water, when pumped up from a height, will sometimes be filled with air which will deposit itself on the plates or paper, rendering photographic operations practically impossible. In this case a large vessel should be filled and allowed to stand several days, or the water should be boiled and then cooled down.

AIR-BRUSH.—A device that can be used by artists for applying liquid color by a jet of air. The distribution of the liquid pigment is made by compressed air.

Paintings or sketches can be made upon any surface and with any liquid color. It has a movable needle which, aside from keeping the color always mixed to the same density, feeds into the atomizing blast the exact amount of color the artist may use. This atomizing blast deposits the color directly upon the surface the artist may be using either in a fine line or broad shadow as he wills, this being under control by the thumb valve.

It must not be understood that this is a mechanical appliance for making pictures. It is merely a tool which gives greater facilities to the artist. The effects obtained are very soft and attractive.

The air-brush is now very largely employed for finishing enlargements and other photographic pictures. It can also be employed in negative retouching.

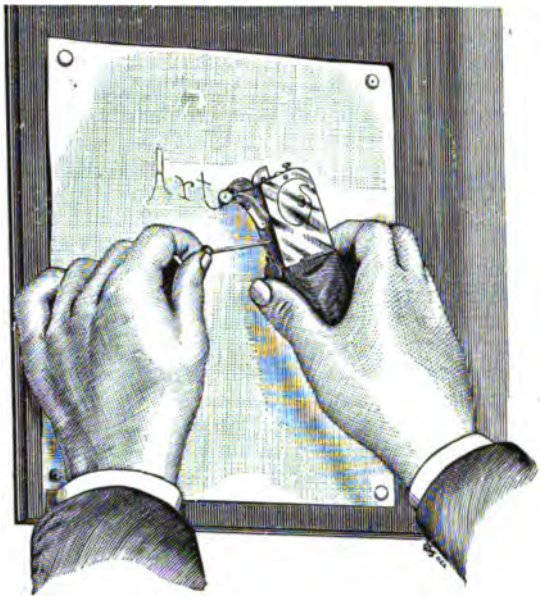


FIG. 23.—THE AIR BRUSH.

ALABASTRINE PROCESS.—A name given by Archer to one of his early invented processes. The collodion negative was, after fixing and washing, placed in a solution of bichloride of mercury and bleached. By backing with a dark substance a positive was produced. The same effect may be obtained with a gelatine negative preferably under-exposed. The hypo, after fixing, is thoroughly eliminated from the negative, and the latter is immersed in a solution of perchloride of mercury 20 grains dissolved in half a drachm of pure hydrochloric acid, and to it is added common salt 10 grains, iron sulphate 10 grains, and distilled water one ounce. When immersed the image immediately whitens. It is then well washed and dried, and either varnished at the back with black varnish or backed with black cloth or velvet. The latter method gives the better result.

ALBEDO.—That proportion of the light that falls upon a surface which is dispersively reflected by it.*

ALBERTYPE PROCESS.—A photo-mechanical process known in this country principally as phototype. It is also worked commercially under a variety of other names. The name Albertype is from Albert, of Munich, the inventor.
See **Phototype.**

ALBUM.—A book composed of leaves, either plain or to which photographs can be affixed, and with openings for their reception. The most suitable albums are those in which the leaves are interchangeable, as shown in Fig. 24. In this the leaves are fastened together with metal wires. Any particular photograph can, if desired, be removed and another one inserted in its place.

FIG. 24.—ALBUM WITH INTERCHANGEABLE LEAVES.

ALBUMEN or **ALBUMIN.**—Albumen is the chief and characteristic constituent of the white of egg (*albumen ori*) and of the serum of blood. Albumen is also present in many other animal and vegetable substances. Commercial albumen is prepared either from the white of egg or from blood serum, the colorless liquid in which the corpuscles are suspended. White of egg consists of transparent, thin walled cellules enclosing an alkaline solution of albuminate of sodium. On beating it up with water, the cellular substance separates in pellicles, while the albuminate of

* Optical Dictionary, in *The Optician*.

sodium remains in solution together with chloride of sodium and phosphate of calcium. In order to remove these mineral substances, the liquid, after being filtered from the cellular substance, is mixed with a small quantity of sub-acetate, of lead which produces an abundant percipitate (an excess of lead salt would redissolve it). This mass, after being washed, is stirred up with water to the consistence of a paste, and carbonic acid gas is passed through the liquid. The albuminate of lead is thereby decomposed, carbonate of lead remains suspended in the liquid, and the albumen in the free state remains dissolved. The solution is filtered through paper previously washed with dilute acid, and as it still retains traces of lead it is treated with a few drops of aqueous hydrosulphuric acid and carefully heated to 140 degs. until it begins to show turbidity; the flocks of albumen thus precipitated carry down the whole of the sulphide of lead. When the liquid, which, after filtration, is perfectly colorless, is evaporated in large capsules at 140 degs. Fahr., a residue is obtained consisting of pure soluble albumen. If the same method be applied to the albumen of blood serum, it does not yield a perfectly pure product. Egg albumen differs from blood albumen by giving a percipitate when agitated by ether, scarcely soluble in strong nitric acid. If dried in the air, it forms a bright yellow, gumlike substance, easily triturated and reduced to a white powder which will not putrefy. It swells up in water like gelatine, but dissolves with great difficulty unless the addition of an alkali be made.

Blood albumen is usually prepared by collecting the blood in a flat-bottomed vessel, where it is allowed to stand for six or eight hours. The serum is then decanted into a filter and received in a vessel having a hole in the bottom of it fitted with a cork, through which a glass tube passes up above the level of the liquid. When the upper portion of the serum becomes quite clear the tube is lowered and the clear serum thus drawn off. It is then evaporated with a gentle heat and is ready for use. The blood of 5 oxen or 20 sheep yields about 2 lbs. of dry albumen.

Albumen is capable of existing in two very distinct modifications, viz., the soluble form, in which it always occurs in the human body, and the insoluble (in water) form. It is impossible to detect any difference between these two varieties, but when coagulation is determined by certain substances, the product is a compound of albumen with the agent used. Soluble albumen may be coagulated or converted into the insoluble form by heating to boiling point or by the action of alcohol or nitric acid. It becomes insoluble in water and alcohol, barely soluble in dilute potash, but soluble in acetic acid. Many of the metallic salts serve to coagulate albumen; nitrate of silver or bichloride of mercury, for instance. The chemical composition of egg and blood albumen is thus given:

Egg Albumen (Mülder).		Blood Albumen.	
Carbon	53.4	Carbon	53.4
Hydrogen	7.0	Hydrogen	7.1
Nitrogen	15.0	Nitrogen	15 6
Oxygen	24.6	Oxygen	22.1
Sulphur	—	Sulphur	1.8
	100.0		100.0

If nitrate of silver is added to a solution of albumen, a white precipitate is formed, caused by the combination of the animal matter with the protoxide of silver, termed albumenate of silver (see **Silver Albumenate**). If heated in a current of hydrogen gas, it assumes a reddish-brown color. Albumen also combines with many other substances. It is preserved by the addition of ammonia or a piece of camphor floated on its surface. Commercial albumen is often adulterated with gum or starch; to detect this adulteration, dissolve the albumen in warm water and add a little acetic acid; if a precipitate be formed, gum is present. Starch may be detected by adding iodine to the solution; it gives a black color.

Albumen is very extensively used for photographic purposes. It serves as a capital substratum to hold the silver salts, and combines with the silver to form silver albumenate. If the silver nitrate bath be too weak, the albumen will become soluble. Egg albumen is the best, though a large quantity of the albumenized paper now sold is prepared with blood albumen; it has a disagreeable smell, however. Formerly it was largely used for glass negatives or positives, but is now used almost solely for paper positive processes, although it is sometimes used in collodion emulsions, owing to its property of giving greater sensitiveness to the film. In photo-mechanical processes it is used on account of its possessing the same property as gelatine, of becoming insoluble on exposure to light when potassium dichromate is added to it.

Albumen is also employed in collodion emulsions owing to the greater sensitiveness it gives to the film, it being a much better halogen absorbent than pyroxlin. Owing to this fact glass, to be coated with a gelatine emulsion containing free nitrate of silver, is previously coated with albumen; it causes the gelatine film to adhere firmly to the glass and prevents the crystallization of the silver nitrate.

It is further of great service for clarifying purposes, because, if boiled with liquids, it coagulates and clutches hold of all impurities and coloring matter, and carries them to the bottom or to the top, according, of course, to the density of the liquid. It is used in France under the tech-

nical name of *glaise*, to impart a gloss to card, paper and other surfaces. Its property of forming a hard compound, when mixed with lime, makes it very useful for compounding cement for laboratory purposes and for mending broken dishes, measures, etc.

TABLE OF STRENGTH OF SOLUTIONS OF ALBUMEN.

Per cent.	Specific gravity.	Per cent.	Specific gravity.
5	1.013	30	1.078
10	1.026	40	1.106
20	1.052	50	1.135

ALBUMENATE OF SILVER.—See **Silver Albumenate.**

ALBUMEN—BEER PROCESS.—A process devised by Capt. Abney and successfully employed by him in Egypt in 1874, when on the expedition to photograph the transit of Venus. For ordinary landscape work it answers admirably, and is very certain in its results. A collodion is prepared with the following formula:

Alcohol .825	12 to 16 ounces.
Ether	12 to 16 "
Pyroxyline	4 drachms.
Ammonium iodide	1 "
Cadmium bromide	2½ "

The relative proportions of ether and alcohol are arranged according to the temperature in which the plates are to be prepared; the warmer the weather the greater must be the proportion of alcohol to the ether. The plate, thoroughly clean, is coated with this collodion and sensitized in—

Recrystallized silver nitrate	2 ozs. 6 drachms.
Water	36 ounces.
Potassium iodide	4 grains.

After sensitizing, the plate is thoroughly washed and the first preservative applied. Formula:

Albumen	3½ ounces.
Water	3½ "
Ammonium hydrate	3 drachms.

This is beaten into froth, and immediately before use is mixed with an equal quantity of ordinary beer or stout and floated over the plate. The superfluous solution is drained off, and the film thoroughly washed under the tap for a couple of minutes, and finally rinsed with a solution of plain beer, to which 1 per cent. of pyrogallic acid has been previously added. The exposure is about the same as required for the wet collodion process, although a greater latitude is permissible. Development may take place any time within a month or so after exposure. The developer is made up as follows:

No. 1.	Pyrogallic acid	15 grains.
	Water	1½ ounces.
No. 2.	Ammonium hydrate .880	1 part.
	Water	4 parts.
No. 3.	Citric acid	1 drachm.
	Acetic acid (glacial)	1 "
	Water	1 ounce.
No. 4.	Silver nitrate	15 grains.
	Water	1½ ounces.

The plate is first washed in water, the temperature of which is not lower than 60 degs. Fahr., and then the developer made up from the four solutions given. To each 2 ozs. of No. 1 add ten drops of No. 2, and after well mixing flow over the plate. The image appears almost immediately. Another seven drops of No. 2 are now added to the solution, which is again floated over the plate. Twenty drops of No. 3 are next poured into the developing cup, and the developer poured into it and well mixed. Again is the plate rinsed, this time by the acidified pyrogallic solution and intensification given by the use of it with No. 4. It is fixed by hyposulphite of soda or by potassium cyanide.

ALBUMENIZE.—To treat with albumen.

ALBUMENIZED PAPER.—Paper coated with albumen, to which salt is added. The introduction of albumenized paper has been credited to Fox Talbot, though the earliest records are to be found in a French work of Le Gray published about 1850. The manufacture of

albumenized paper has now become a not unimportant industry, although by far the greater quantity is made abroad, chiefly in Dresden. The low price at which the ready prepared paper is sold makes it far cheaper to purchase than to make it oneself. The paper used must be homogeneous throughout, and of a fine texture and quality. The surface must be uniform, smooth, and entirely free from all chemical impurities, which, by decomposition, when treated with other chemicals, would spoil the picture. The two most suitable kinds are Saxe and Rive paper. This paper is rolled with cylinders composed of hard paper pulp. If the paper be rolled with metal rollers fine metallic dust impregnates the paper. This is invisible until treated with the silver nitrate, when a combination takes place and black spots become visible. To prepare the paper, take the whites of fifteen eggs, which must be absolutely fresh, crack each egg separately in a cup, remove the yolk, and place the white into another vessel before cracking the next; remove any impurities with a glass rod, and ascertain the number of ounces. There should be about fifteen, as a good-sized hen's egg will yield about an ounce of albumen. It may be necessary, however, to break another one to make up the fifteen ounces. Next dissolve 150 grains of ammonium chloride with half an ounce of alcohol and four and a half ounces of water, and add to this the albumen. Beat the mixture into a thick white froth with an egg-beater, then allow it to stand and the deposit in the albumen to settle. It is then filtered through a sponge or piece of cotton wool (previously well washed in distilled water) and poured into a flat, low-edged dish, a few inches larger than the size of the paper to be prepared. Much care is necessary in laying the paper upon the albumen to avoid the formation of air bubbles. Each sheet of paper, cut into a convenient size, is laid hold of at opposite corners with the finger and thumb of each hand, and the two hands brought close together, giving the paper a convex surface. See Fig. 25. It is then lowered on to the albumen until the middle of the paper touches it; the hands are then separated and brought down until the whole of the sheet floats upon the albumen, except a small corner which is turned up for convenience in laying hold of the sheet again to remove it. After the paper has laid on the albumen for a few seconds, it is lifted up half-way, and the air-bubbles removed with a small camel-hair brush dipped in the albumen; it is then laid carefully back again and the other half treated in the same way. All air-bubbles removed, the sheet must be allowed to rest on the solution for about a minute. It is then lifted up by the turned-up corner and hung up by two corners to dry. If the paper be dry, and the weather also very dry, the albumen does not attach itself very easily to the paper, and in this case, although a sheet has been properly floated, the top part will allow the albumen to run off, so that the film is much thinner at the top than at the bottom. To obviate this the sheet should be suspended by its broadside. American clips attached to wires stretched across the room serve admirably to attach the paper to. When dry the prepared paper is rolled between steel rollers and packed away flat. Paper prepared in this manner is what is termed single albumenized paper. Double albumenized paper is made by coagulating the first layer of albumen by steam, and repeating the operation.

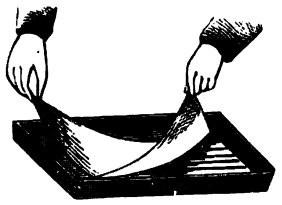


FIG. 25.

ALBUMEN PROCESS.—The albumen glass positive process is still much used for making transparencies, lantern and stereoscopic slides. The manipulations may be carried on in a yellow light, it being more pleasant to work in than the red. First prepare a solution of albumen by breaking up eggs separately and removing the yolks. When 12 ounces of the whites have been collected, place in a convenient vessel and add half a drachm of glacial acetic acid diluted in one ounce of water. Stir it well with the albumen with a glass rod for about two minutes, a little care being taken that froth is not produced. The addition of the acetic acid causes a flocculent deposit, which in about an hour collects itself in a mass at the top of the solution. This is easily removed with pieces of paper, and the albumen should be perfectly clear and rather limpid. Strain through linen and add 50 minims of ammonia sp. gr. .880 to restore the viscidity destroyed by the acid. The next addition is one drachm of ammonium iodide and eight grains ammonium bromide. When these ingredients are dissolved, the albumen is ready for use at any time if kept in well-corked bottles, remaining good for at least a year.

We must next select the glass. If for lantern slides it must, of course, be of a better quality, and free from bubbles or other impurities. This is coated with a plain collodion, and as soon as the film has set the whole is plunged in a dish of cold water, where it is allowed to remain from four to five minutes. Each glass so coated and treated is next rinsed under a tap to remove all apparent greasiness, and then stood up on end on a pad of blotting paper.

The albumen is next filtered through cotton wool (a small tuft being placed in the neck of a funnel) into a glass measure. A little of it is then poured on the upper end of the plate and made to flow over the whole of the film in one continuous wave, driving the water before it off the plate into the sink, and following it itself. Drain the plate well, and then pour on a fresh portion of the albumen, and let it flow backward and forward to allow it to soak well into the porous collodion film; then drain it off into a measure and place the plate carefully in a rack. Coat as many as will be required for some time, as they will keep for a lengthy period. The

rack containing the plates should be placed in a warm room to allow them to dry, and as soon as they dry they are placed before a fire and made as hot as the hand can possibly bear. The object of this is to prevent the film blistering during the subsequent treatment, and it is a very effective means. The plates have next to be sensitized. In one pint of distilled water dissolve four grains of potassium iodide and add 2 ounces of silver nitrate. When this has dissolved, add 2¼ ounces of glacial acetic acid, and the sensitizing bath is ready for use. The plates can be laid in a dish containing the solution, but, if possible, use a dipping bath, as described in the wet collodion manipulations. The time of immersion should not exceed half or three-quarters of a minute. When taking from the sensitizing bath the plates are placed in a dish of distilled water to remove the free silver nitrate. They are then well rinsed under a tap and again placed in the drying rack. These sensitized plates may be made to keep if treated with a solution of gallic acid. If the sensitizing bath becomes discolored, as it will do if many plates are prepared in it, shake up a little kaolin in it, and the discoloration will disappear, and the bath resume its pristine efficacy.

Printing is usually done by superposition. The exposure differs, of course, with the quality of the negative and the light. A negative of medium density will require, at one foot from an ordinary fish-tail gas burner, an exposure of between ten to twenty seconds. Practice alone enables one to judge correctly, and with plates of this description there is a great latitude.

For development, prepare two solutions, the first containing three grains of pyrogallic acid dissolved in one ounce of water; and the second five grains of silver nitrate and five grains of citric acid dissolved in one ounce of distilled water. Label these 1 and 2 respectively. First flood the plate with water containing a few drops of Solution 2 until the film is thoroughly permeated. Pour it away and replace by Solution 1, to each ounce of which four drops of Solution 2 have been added. In about a minute the image should make its appearance. When all the details are visible, pour the developer into a measure and add to each ounce half a drachm of Solution 2. Mix, and pour on and off the plate until the image has attained the requisite density. This should, however, be very slight, as the color is obtained in the toning.

The toning bath consists of two ounces of sodium hyposulphite dissolved in eight ounces of water, and when dissolved, four grains of gold chloride added gradually, stirring rapidly the while. The addition of 30 grains of silver nitrate dissolved in an ounce of water has been recommended as improving the color obtained in toning. After mixing the toning bath it must be allowed to stand for at least 12 hours. In toning, the plates are placed in a dish, and the solution poured over them. The process is a very slow one; half an hour is sometimes required to obtain a rich black tone. In regulating the density of the toning it is necessary to remember that the pictures appear much denser when dry than when wet. The toning bath will keep for any length of time; it improves, in fact, by keeping, and when inclined to be weak add a little more gold. This must be done, however, 10 or 12 hours before using. When the desired tone has been attained, the plates are well rinsed under the tap, and afterward left to soak for a little time in several changes of water to thoroughly eliminate the hypo from the film.

Albumen transparencies should not be varnished, but mounted with a protecting glass.

ALCOHOL (Formula, C_2H_6O; molecular weight, 46; synonyms, *ethylic alcohol, aqua vitæ, spirits of wine*).—Alcohol is obtained by carefully distilling any spirituous or fermented liquor. If wine or beer be placed in a suitable retort and heat applied, the alcohol may be separated from the less volatile matter, and thus obtained it is known in commerce as "rectified spirits of wine." Its specific gravity is usually about 0.840 to 0.850, and it generally contains about 17 to 20 per cent. of water, because although the alcohol is far more volatile than the water, and rises first and is condensed in the receiver, yet a portion of the water also passes over with the alcohol in the proportion already mentioned, and dilutes it to that extent. This water may be removed by adding to it carbonate of potash until that salt ceases to dissolve. This mixture is then thoroughly shaken, and when allowed to stand at rest soon separates into two portions—the uppermost part is the alcohol and the lowermost an aqueous solution of the carbonate. The alcohol portion is then carefully drawn off by means of a syphon and poured upon a quantity of powdered quicklime of the same weight as the alcohol, and previously placed into a tabulated retort. This is allowed a day or two to digest, and then slowly distilled in a water bath at a temperature of about 200 deg.

Alcohol is a limpid, colorless liquid, of an agreeable odor and a strong, pungent taste. From its action on the system it may be termed poisonous, and if diluted it is very intoxicating. It absorbs vapor of water, and becomes diluted by exposure to damp air; it requires, therefore, to be kept in a well-stoppered bottle. It has never been frozen. It is extremely inflammable, and burns with a pale bluish and smokeless flame, scarcely visible in daylight, but the heat of the flame is very intense.

The best test for alcohol is to mix with a little solid iodine and then to add a weak solution of caustic potash until the liquid is nearly decolorized. On stirring a yellow crystalline precipitate of iodoform will be formed.

The uses of alcohol in the photographic art are very numerous. Besides many other purposes to which it is put its power of dissolving pyroxyline (gun-cotton) and various gum lacs

and resins causes it to be largely used in the manufacture of collodion and different varnishes. It acts as a preservative of pyro, owing to the fact that atmospheric oxygen does not dissolve in it as rapidly as in water. It is used for drying negatives quickly on account of its strong affinity for water. It has also a hardening effect on gelatine and is used in the prevention of frilling.

Alcohol is also added to dry plate emulsions. It causes them to flow more evenly over the glass plates and accelerates the drying process. About 5 per cent. is the usual quantity. If too much be added, it will cause spots. Alcohol in a gelatine emulsion also acts as a preservative while the emulsion is in the jelly state.

It is not really essential that absolute (pure) alcohol should be used for all photographic purposes, as it is very expensive to manufacture. A spirit that contains less than 4 per cent. of water is quite pure enough, and may be obtained by agitating commercial spirits of wine with carbonate of potash, and then with quicklime in the manner already advised.

The principal impurity in commercial alcohol is fusel oil. This may be detected by first distilling nine-tenths of the alcohol at lowest possible temperature; the residue is then allowed to cool thoroughly and shaken up with an equal volume of pure petroleum ether. The upper layer of ether is syphoned off into an evaporating dish and evaporated to dryness at 80 deg. C., when fusel oil will be at once detected in the residue by its unpleasant and characteristic smell *

Rectified Spirit (Formula, C_2H_6O) contains 16 per cent. of water and 84 per cent. of alcohol. Sp. gr. about .838.

In rectifying spirits, it is sometimes, for economy's sake, adulterated with a liquid known as "faints," and as these faints are usually contaminated with essential oils, it is necessary that such should be avoided. Grain spirit is to be preferred, the specific gravity of which varies from .817 to .819 at 60 deg. Fahr. Its smell is very sweet, and although it may not be strong enough for many purposes, a portion of it can be converted into alcohol of .805 by means of dry chloride of calcium, and this mixed with the remainder. The re-action to test paper of this spirit should be quite neutral; but if, as sometimes happens, a trace of acid is present, one drop of a solution of ammonia, sp. gr. 0.93, will neutralize it.

The following table shows the quantity of absolute alcohol (sp. gr. .796 at 60 deg.) contained in diluted alcohol of different specific gravities:

Alcohol.	Water.	100 Parts Specific Gravity	Alcohol.	Water.	100 Parts Specific Gravity.	Alcohol.	Water.	100 Parts Specific Gravity.
100	0	.796	66	34	.881	32	68	.955
99	1	.798	65	35	.883	31	69	.957
98	2	.801	64	36	.886	30	70	.958
97	3	.804	63	37	.889	29	71	.960
96	4	.807	62	38	.891	28	72	.962
95	5	.809	61	39	.893	27	73	.963
94	6	.812	60	40	.896	26	74	.965
93	7	.815	59	41	.898	25	75	.967
92	8	.817	58	42	.900	24	76	.968
91	9	.820	57	43	.902	23	77	.970
90	10	.822	56	44	.904	22	78	.972
89	11	.825	55	45	.906	21	79	.973
88	12	.827	54	46	.908	20	80	.974
87	13	.830	53	47	.910	19	81	.975
86	14	.832	52	48	.912	18	82	.977
85	15	.835	51	49	.915	17	83	.978
84	16	.838	50	50	.917	16	84	.979
83	17	.840	49	51	.920	15	85	.981
82	18	.843	48	52	.922	14	86	.982
81	19	.846	47	53	.924	13	87	.984
80	20	.848	46	54	.926	12	88	.986
79	21	.851	45	55	.928	11	89	.987
78	22	.853	44	56	.930	10	90	.988
77	23	.855	43	57	.933	9	91	.989
76	24	.857	42	58	.935	8	92	.990
75	25	.860	41	59	.937	7	93	.991
74	26	.863	40	60	.939	6	94	.992
73	27	.865	39	61	.941	5	95	.994
72	28	.867	38	62	.943	4	96	.995
71	29	.870	37	63	.945	3	97	.997
70	30	.872	36	64	.947	2	98	.998
69	31	.874	35	65	.949	1	99	.999
68	32	.875	34	66	.951	0	100	.1000
67	33	.879	33	67	.953			

To get the exact measurement, other impurities must not be present, but must first be removed by distilling seven-eighths of a measured volume of the spirit and adding sufficient water to make up the original volume.

* C. J. Leaper, in "Materia Photographica."

ALCOHOL, Methylated. Synonym, *methylated spirit.*—Spirits of wine, to which is added 10 per cent. of wood naphtha to prevent its being used internally, is, in England, allowed by the Excise laws to be sold free of duty, under the name of methylated spirit. It is, however, very inferior in quality, but can be used in many of the photographic operations, except for addition to silver compounds.

Methylated alcohol can be distinguished from pure alcohol by its smell and by its turning brown when mixed with its own volume of sulphuric acid.

ALCOHOL, Methylic (Formula, CH_4O; molecular weight, 32). Synonyms, *wood naphtha pyroxylic spirit, Pyroligneous ether, wood spirit.*—A product of the destructive distillation of wood, and constitutes a larger portion of wood naphtha or pyroxylic spirit. When pure, it closely resembles common naphtha. In commerce it is met with as a brown inflammable liquid, possessing a characteristic odor, has a sp. gr. of .798 at 68 deg. Fahr., and boils at 151 deg. Fahr.

ALCOHOLIZE.—To reduce a body to an impalpable powder. To rectify spirits until they are completely deprived of any water commingled with them.

ALCOHOLMETER, alcoholometer, alcohometer, or alcometer.—An instrument devised by Gay Lussac for measuring the proportion of pure alcohol which spirituous liquors contain.

ALDEHYDE—alcohol deprived of hydrogen.—Aldehydes differ from alcohols in having two atoms less of hydrogen, which are removed from the carbon atom containing the radical HO connected to it in the form of alcohol. Aldehyde is sometimes found in acetic acid. It is a powerful deoxidizing agent, and was used to improve the tone of collodion positives by removing organic matter from the picture, and reducing it more completely to the metallic state. It is now but little used.

ALETHOSCOPE.—An optical instrument, the use of which renders pictures more lifelike and natural in appearance.*

ALIZARIN (Formula, $C_{14}H_8O_4$).—The chief coloring matter of madder. It can also be artificially prepared from anthracene, a white solid contained in tar. It crystallizes in red prisms slightly soluble in water and alcohol. It is used in orthochromatic photography, and also for coloring carbon tissue.

ALKALI.—The term alkali is given to many substances which are the antithesis of acid, and are capable of neutralizing it, or, if the acid be weak, give alkaline reaction. The three principal ones are sodium, potassium and ammonium. Alkalies turn red litmus paper blue, and turmeric paper brown. They serve to throw down metals dissolved in acids, as oxides or hydrated oxides, and readily unite with acids to form salts.

ALKALINE DEVELOPMENT.—See **Development.**

ALLOCHROIC.—Changeable in color. Allochromatic, allochromic.

ALLOMORPHISM.—Change of form without alteration in chemical constitution.

ALLOTROPIC.—A substance is said to be allotropic when it exists in several different states distinguished from each other by different properties. Thus, carbon, as a diamond, exists in the form of the hardest of minerals, and also of charcoal. Phosphorous, again, can appear under at least three different forms, one waxlike, very fusible and combustible; another red, friable and much less combustible; and a third, crystalline form. The changes are generally regarded as evidences of a change in the molecular structure. This variation of properties exists in many substances. Carey Lea recently made known many interesting experiments in various allotropic forms of silver. Many new facts were thereby discovered, which may probably assist in solving the mystery of the latent image.

ALLYL, SULPHO-CARBAMIDE.—Prepared by mixing essential oil of mustard with six times its volume of liquid ammonia. The mixture thus formed is well agitated and then allowed to stand for several hours in a stoppered bottle, until the oil has absorbed as much of the ammonia as possible. The solution in then placed in a flat capsule in order to allow the disengagement of the ammonia in excess. It is then filtered and evaporated to obtain the crystallized product. The crystals are finally purified by recrystallization.†

Waterhouse has shown that a few drops of a saturated aqueous solution of sulphocarbamide of allyl will reverse the image and give a direct positive in the camera. An exposure one-fortieth part of the usual time is sufficient; consequently instantaneous pictures can be made.

ALPHA PAPER.—A name given in England to a printing paper coated with a gelatine film, in which is contained a combination of silver with a chloride and a bromide. It is used for

* Optical Dictionary, in *The Optician.*

† "Photographic Mosaics 1894."

obtaining positives by artificial light, and is subjected to much the same treatment in development as bromide paper (see **Bromide Paper**). An exposure somewhat more protracted is, however, necessary, owing to the presence of a chloride in the film. The same amount of careful attention and cleanliness is, however, necessary to obtain good results. The following formula* has been given for the preparation of the emulsion :

SOLUTION 1.

Silver nitrate	100 grains.
Citric acid	100 grains.
Distilled water	3 ounces.

Dissolve both solids in the water and filter through well-washed filter paper.

SOLUTION 2.

Sodium chloride	17 grains.
Potassium bromide	40 grains.
Citric acid	100 grains.
Nelson's gelatine	40 grains.
Distilled water	3 ounces.

Allow the gelatine to swell in cold water for thirty minutes, heat to 150 degs. Fahr., add salts and acid, and then in the dark-room pour Solution No. 1 into No. 2 always. Constantly stirring, add to the mixture, while still hot, Nelson's gelatine 100 and Heinrich's gelatine 100 grains, previously swollen in water. When dissolved, pour into a flat dish, cut up into small pieces, or squeeze through netting, and wash as in an ordinary emulsion. Remelt and coat the paper. For methods of washing emulsions, see **Emulsion**, and for coating the paper, see **Gelatino-Chloride Printing-Out Process.**

The ferrous-oxalate developer gives the best tones, but, if the clearing bath be used, an alkaline developer may be employed. After developing, the prints should be well treated with an alum and acid bath to clear away all yellowness; then they may be toned in a gold or platinum bath. After that the usual method of fixing, varied in length of time in certain cases, according to the color that is required, warm or cold; finally, a thorough washing in several changes of water. They may afterward be allowed to dry spontaneously, with a dull surface, or given a polish in the same manner as recommended for Aristotype Prints. The favorite oxalate developer is the following :

SOLUTION 1.

Saturated solution of oxalate of potash	2 ounces.
10 per cent. solution of ammonium bromide	60 to 180 drops.
Water	½ ounce.

SOLUTION 2.

Saturated solution of iron sulphate	½ ounce.
Tartaric acid	10 grains.
Water	3½ ounces.

After development, the prints are immersed in the clearing solution :

Alum	4 ounces.
Citric acid	1 ounce.
Warm water	80 ounces.

This must be cold. Then wash for five minutes, and fix and tone in following combined bath :

Water	10 ounces.
Soda hyposulphite	2½ ounces.
Acetate of soda	4 drachms.
Ammonium sulphocyanide	1 drachm.
Gold chloride solution (15 grs. to 1 oz. water)	4 drachms.

Instead of toning, a variety of other colors can be obtained by development. Brown tones are produced by adding common salt and citric acid to the developer; red prints by the addition of ammonia. Other colors can be obtained by variation in the exposure and restraining development.

ALTISCOPE.—An optical instrument having an elevated, inclined mirror, by the aid of which it is possible to look over near objects standing in the line of vision.

ALTITUDE.—Altitude is an important although barely recognized factor in the calculation of exposure. Bunsen discovered that the actinicity of the light increased proportionately with the increase of the altitude above sea level, and Professor Ehrmann has pointed out* that, at Colorado, an exposure meter proved an absolute failure on account of the high situation of

* G. D. Wall, in "Index Rerum," by Dr. Janeway.

that place. At a spot 1,500 feet above the level of the sea, two seconds' exposure was sufficient to expose a plate that, with the same conditions at sea-level, required at least three seconds.

ALTO RELIEVO, or **ALTO RILIEVO.**—A term used principally in photo-sculpture. The term should only be applied when the figures project more than half their true proportions. When they project, exactly one-half, the term used is *Mezzo relievo*, and if less then half, *Basso-relievo*, or, in English, *Bas-relief.*

ALUM.—The name given to double salts of aluminium with sulphates of potassium, sodium, and ammonium, or of other monatomic metals, as silver, thallium, etc. They crystallize in octohedra. The alums of commerce are potash alum (formula $Al_2K_2(SO_4)_4 + (12H_2O)$ and ammonium alum ($NH_4Al(SO_4)_2 12H_2O$). Large quantities are manufactured, principally at Hurlet, near Glasgow, and Whitby in Yorkshire. It is prepared by the double decomposition of shale containing iron pyrites FeS_2, which is gently burnt, and exposed to the air in a moist state. It oxidizes and forms sulphates, and on the addition of a potash salt or ammonium sulphate to the solution obtained by water, alum crystallizes out. It is then purified by three successive recrystallizations. Ammonium alum can be distinguished from potash alum by its giving off ammonia when warmed with sodium hydroxide.

Alum has an astringent and acidulous taste, is styptic, and reddens litmus paper. It dissolves in about six times its own weight of boiling water, but to only about 10 per cent. in cold. It is insoluble in alcohol and ether.

Alum possesses the peculiar property of hardening gelatine and rendering it insoluble. Combined with citric or other acids, it serves for clearing and hardening gelatine negatives that have become discolored by the action of the developer. A small quantity of potash alum added to the silver sensitizing bath used for albumen paper prevents scum forming, and by at once coagulating the albumen causes the print to be more on the surface of the paper.

TABLE OF DENSITIES OF AQUEOUS SOLUTIONS OF POTASH AND AMMONIA ALUM AT 17.5 CELSUS.*

Potash Alum, Sp. Gr.	Ammonium Alum. Sp. Gr.	Percentage.	Potash Alum. Sp. Gr.	Ammonium Alum. Sp. Gr.	Percentage.
1.0065	1.0060	1	1.0218	1.0200	4
1.0110	1.0109	2	1.0269	1.0255	5
1.0166	1.0156	3	1.0320	1.0305	6

Chrome Alum (Formula, $CrK(SO_4)_2 + 12H_2O$)—symbol, *potassium chromic salphate*—molecular weight, 999, is obtained as a secondary product in the oxidation of substances by potassium bichromate and sulphuric acid, and is formed in the bichromate battery.

It can be made on a small scale by dissolving 3 ounces of bichromate of potash in 10 ounces of boiling water and gradually adding 4½ ounces of strong sulphuric acid, followed by half an ounce of pure alcohol added by drops. Evaporate until the solution measures about 5 ounces, and then put aside for a few days, when the crystals of chrome alum will separate out. They should be rinsed in cold water to free from any sulphuric acid that may be left.

This salt forms large dark-purple octahedral crystals, which exhibit a ruby color by reflected light. It is soluble in about 10 parts of cold water; it decomposes in hot, and is insoluble in alcohol. Chrome alum is also used for hardening and rendering gelatine insoluble, for which purpose it is superior to potash alum.

DENSITIES OF CHROME ALUM SOLUTIONS (FRANE).

Specific Gravity.	Percentage.	Specific Gravity.	Percentage.
1.0174	5	1.1896	40
1.0342	10	1.2984	50
1.0746	20	1.4566	60
1.1274	30	1.6362	

Liesegang has discovered† that if paper be impregnated with potash alum, and exposed for three minutes to sunlight, such a change takes place in those parts of the paper upon which the light has acted that they are able to slightly reduce nitrate of silver. If heated with gallic acid these parts become black, the rest remaining white.

ALUM BATH.—An alum bath may be prepared by placing a handful of potash alum in a 20 ounce bottle and filling it up with water, replenishing with the latter whenever the solution is

* Eder's "*Jahrbuch der Photographie.*"

† "*Photographisches Archiv.*"

used. By this means a saturated solution is always at hand, and it is often of great use in an emergency to check the frilling of plates or the blistering of paper.

ALUMINIUM (Symbol Al; atomic weight, 27.5)—The metallic base of alumina. It is obtained principally for the purpose of commerce by the decomposition of aluminium chloride by sodium. It is extremely light, and is now being used for lens mounts. It has the advantage over brass in lightness and appearance. A brass-mounted lens weighing 7 ounces would, with an aluminium mount, weigh but 3. It is extremely difficult to work with and its durability is open to question. It is also very difficult to solder. The best results have so far been obtained with an alloy of zinc tin aluminium and phosphorous.

Powdered aluminium is now recommended for flash-light purposes. It is said to give a more brilliant light than magnesium, and to be free from the obnoxious vapors usually produced.

The aluminium bronze powders of commerce can be employed,* provided all greasy matter is drawn off by subjecting to heat. The following formula is recommended: Powdered aluminium, 30 parts; potassium chlorate, 70 parts. After mixing, the compound should be handled carefully, as there is always a danger of explosion. The aluminium powder should be heated in an iron pan sufficiently to drive away all greasy matters. A combination of magnesium and aluminium has been recommended by Wladiminsky, in the *Photographische Rundschau:* 70 parts of potassium chlorate; 40 parts of potassium perchlorate; 45 parts of magnesium, and 20 parts of aluminium, are powdered separately, and, after a careful mixture, made up into small cartridges. A small tuft of gun cotton is placed at the bottom, and acts as a fuse.

ALUMINIUM CHLORIDE (Formula Al_2Cl_6).—Prepared by heating a mixture of carbon and alumina in a current of dry chlorine. A white crystalline solid, hygroscopic and emitting fumes of hydrochloric acid. It is readily soluble in water, alcohol and ether; and has been recommended as a substitute for potash or chrome alum, owing to its property of hardening gelatine. It is said that a small quantity added to the developer when working with gelatine films serves to harden the latter and give more detail although prolonging development.

A small quantity of aluminium chloride added to the amidol developer partially neutralizes it and acts as a restrainer and assists in giving greater detail.

It has also been recommended as an addition to the gold toning bath. Thirty grains of aluminium chloride are dissolved in 20 ounces of water and the solution made alkaline; allow it to settle, filter, and add sufficient gold chloride for the number of prints to be toned, reckoning 1 grain to the sheet. Its action here is also open to question, as it is decomposed by all alkalies or alkaline carbonates with the formation of aluminium hydroxide.

ALUMINIUM SULPHATE (Formula $Al_23(SO_4),18H_2O.$)—Formed by dissolving aluminium hydroxide or sulphuric acid. It is sometimes recommended as a substitute for alum for hardening gelatine prints and emulsions.

AMACRATIC.—A term used in optics for uniting the chemical rays of light into one focus.

AMALGAMATE.—To unite or *alloy* a metal with quicksilver.

AMALGAM FOR SILVERED MIRRORS.—See **Mirrors.**

AMASTHENIC.—Uniting the chemical rays of light into one focus. See **Amacratic.**

AMATEUR.—The dictionary meaning of the word amateur is "One who follows any science, art or occupation, not from pecuniary motives, but from a love of it, and who, as a rule, is not so proficient in it as if he had to depend upon it for a livelihood." An amateur photographer has been designated "a spoiler of photographic dry plates"; but it is nevertheless true that a large number of the great body of amateur photographers have succeeded in turning out very high-class work, and, except in portraiture, often superior to that of professionals. This is no doubt owing to the fact that they are able to give more time and attention to details than the ever-busy professional photographer. Nor do a great many of them object to making a little money with their labor. The question as to whether these have any right to the title of "amateur" has already occupied many columns of the photographic journals, but, apparently no definite decision can be arrived at.

With the wet collodion process of photography there were few amateurs. On the introduction of the dry-plates, however, and the many improvements with regard to the apparatus in order to make it as portable as possible, photography has been made to yield delight to thousands of men and women in this country, for the members of the fair sex do not intend to be left behind—they are often possessed of artistic taste to a considerable degree, and have the advantage over men with their natural neatness and dexterity. It must also be stated that to amateur photographers is due the credit of a very great number of inventions and improvements.

* A fine aluminium powder is sold under the name of "silver bronze," and is very suitable for the purpose *Bolas.*

AMBER (Synonym, *succinite*).—A fossil resin from an extinct pine, *Pinites succinifer*. A hard brittle substance, generally yellow, but sometimes reddish-brown or whitish and clouded. The chief supplies come from the Baltic. It is used for preparing a varnish, being soluble in chloroform or ether. See **Varnish.**

AMBROTYPE..—An old term for a picture on glass made by the collodion positive process with another piece of glass as a protector cemented to it with Canada balsam.

AMETALLOUS.—Non-metallic.

AMIDOL.—The trade name for diamidophenol (Formula, $C_6H_8O_2$), molecular weight, 124). —A white crystalline powder, easily soluble in water, giving a colorless solution having an acid reaction. It was first discovered by Gauche as early as 1869. He prepared it by reducing dinitrophenol by means of iodophosphorous.* Its power as a developing agent for bromide plates was discovered by Dr. Andresen in 1890. Solutions of amidol quickly discolor by absorption of oxygen from the air, and, therefore, require the addition of a sulphite as a preservative. Amidol is also slightly soluble in alcohol. Ferric chloride turns its solution to a deep red color, and bichromate of potash changes it to a brownish red, a precipitate being formed. According to Colonel Waterhouse, alkalis turn the solution green. With carbonate of lithia and ammonia, the green color darkens and then gradually becomes a bright yellow, which afterward darkens.

Amidol, mixed with water and neutral sodium sulphite, acts as a powerful developing agent, superior in some respects to pyro and other developers. It is particularly remarkable in the fact that it has a slight developing action for gelatino-bromide plates even without the addition of an alkali, the solution, in fact, giving an acid reaction. It is for this reason especially suitable for plates having a tendency to frill.

Amidol gives negatives of a grayish-black color and very transparent in the clear parts. Its action, however, is very powerful, and for this reason it has been stated that the exposure can be somewhat less than that required with other developers. This possibility has not, however, been absolutely decided. The image flashes up almost immediately the plate is immersed in the solution, and, unless accustomed to its use, one is likely to imagine the plate to have been hopelessly exposed. Its continued action, however, is to strengthen the parts necessary, and a brilliant negative is the final result. As there is less loss of density in fixing after development with amidol than with other developers, it is not necessary to carry it so far.

For use with amidol, it is advisable to employ the purest form of sodium sulphite. The common kinds contain a very large percentage of carbonates.

Bromides have a restraining action upon amidol developers, but much larger quantities must be added to effect this than with other developers. A small quantity will, however, prevent fog. According to Eder, acids, like sulphuric or citric, and acid bisulphite of sodium, restrain development. Small quantities, however, have but little effect, and large ones stop the developing action altogether.

The addition of a weak alkali accelerates development.

Amidol mixed with sodium sulphite will remain good for several weeks. A convenient form of preparing it is to keep on hand a solution of neutral sulphite and add the amidol to it as required. One ounce of developer should contain from 2 to 3 grains of amidol.

AMIDOL DEVELOPER.

Dissolve 10 ounces of neutral sodium sulphite in crystals (Andresen's) in 50 ounces of distilled water, and add 1 ounce of amidol. Dissolve, filter quickly, and fill up in small bottles. For use, dilute with from 2 to 4 volumes of water. Do not spare bromide of potassium.

DR. STOLZE'S AMIDOL DEVELOPER.

A.—Distilled water	100 Gm.
Potassium metabisulphite	25 Gm.
Amidol (Andresen's)	5 Gm.
B.—Distilled water	100 Gm.
Potassium bicarbonate	20 Gm.

To 100 C.c. of water add 100 C.c. of A, and of B from 5 to 50 C.c., according to time of exposure. For normal exposures, 20 C.c. are sufficient. Do not apply the solution till effervescence has ceased. For other formulæ see under **Developer.**

AMIDOL CARTRIDGES.—Small packages made in the form of cartridges, and containing the necessary ingredients for the amidol developer. The different substances are separated from each other by means of tufts of cotton wool. When the whole contents are removed and dissolved in a certain quantity of water, the developer is found ready for use. They are very convenient in traveling.

* Liebig's "*Annales de Chemie*," 147, 66.

AMMONIA (Formula, NH_3; atomic weight, 17.01. Synonyms, *spirits of hartshorn, volatile alkali*).—The name is supposed to be derived from *Ammonia*, the district of Libya, where it was first prepared, or from its being first manufactured from camel's dung collected by the Arabs at the Temple of Jupiter Ammon in the same locality.

Ammonia exists in the air as carbonate of ammonium ; in rain water, especially in that of thunder showers, as nitrate ; in sea water, and in many of the mineral springs. It is present in most kinds of clay and soils, in sesquioxide of iron, and in the majority of iron ores. Sal ammoniac and ammonium alum are found as minerals, the former chiefly in volcanic regions and in some specimens of rock salt. Ammonia is obtained by the dry distillation of animal or vegetable matter containing nitrogen. The horns and hoofs of animals produce large quantities, and for this reason it is sometimes called *spirits of hartshorn*.

Urine is, no doubt, the oldest source of ammoniacal compounds, as sal ammonic prepared from it was an article of commerce in Europe as early as 1410. The methodical collection of urine and working it up into ammoniacal compounds, have been carried out in the neighborhood of some large towns, *e.g.*, Paris, according to a work entitled "Industrie des Produits Ammoniacaux," we find that in Paris there are daily 2,200 tons of urine and night soil taken out of the *fosses* and left to settle in large reservoirs. Sulphate of iron or zinc is used as a disinfectant, and the solid matter is separated from the liquid sewerage forming 85-95 per cent., which is now called *eau vanne*. In three or four weeks the fermentation is complete, the urea has vanished, and there has been formed principally ammonium carbonate, along with sulphydrate, sulphite, chloride, ammonio-magnesian, phosphate compound ammonias, and other substances of intensely disagreeable smell.

Large quantities of ammonia can be extracted from Peruvian guano, but its value as a manure is so great that the process of extraction patented by Young, in 1841, can never be remunerative.

Ammonia is also obtained from peat, from bituminous shale, and as a by-product in the manufacture of beet-root sugar.

In England ammonia is chiefly obtained from gas liquor. In the dry distillation of coal, as practiced in gas works for obtaining gas for illuminating purposes, it is necessary to purify the gas by subjecting it to a cooling and washing with water. In this process two products are obtained from the gas—an oily and an aqueous substance which, by settling in the tanks, separate from each other and form tar and gas liquor, in which many ammoniacal substances are contained.

Ammonia is a colorless gas of an extremely pungent smell, and sharp alkaline taste. It contains one atom of nitrogen, combined with three of hydrogen, which two elementary bodies show, when free, no tendency to combine, but can be made to unite under certain circumstances, the result being ammonia. These elements, however, may be decomposed by the electric discharge, or very slowly by heat. Ammonia gas does not support either combustion or respiration. Animals die when immersed in it. It is feebly combustible ; when issuing in a fine stream into air it may be kindled, and burns with a pale flame. It colors turmeric paper brown, and turns red litmus paper blue, both colors disappearing on exposure to air. Taste hot and strongly alkaline, and is poisonous when breathed—it destroys the mucous membrane.

Liquid Ammonia is an aqueous solution of the volatile gas ammonia, and in this state is generally used in photography. Water at ordinary temperature absorbs about 700 times its volume. A fluid dram of ammonia liquor fortior contains 15.83 grains of ammonia, and has a sp. gr. of 0.891. The liquor ammonia of the pharmacopœia has a sp. gr. of 0.959, and a fluid dram contains 5.2 grains of NH_3. It is a common error to confound these two, but it will be seen that the ammoniæ liquor fortior contains 200 per cent. more ammonia. Liquor ammonia is extremely alkaline, but differs from the other alkalies in the fact of its being volatile.

Commercial Aqueous Ammonia differs in many ways, and contains certain impurities. The sp. gr. diminishes of course with the amount of ammonia present, but should be about .940. A table is given, however, at the conclusion of this article to enable one to determine the quantity of ammonia present by the specific gravity of the liquid. Solution of ammonia absorbs carbolic acid rapidly from the air, forming carbonate of ammonium. It is therefore necessary to keep in a well-stoppered bottle, and to avoid leaving the mouth open as much as possible. A good plan is to smear the stopper with vaseline, which makes it fit perfectly close, and prevents it from becoming fast.

Aqueous ammonia may contain the following impurities : Chlorine, which may be detected by adding a small quantity of nitrate of silver ; it gives a cloudiness. Lime, which gives a precipitate with oxalic acid left as a solid residue on evaporation. Empreumatic oil ; it then has a yellow color and a disagreeable smell.

Pure aqueous ammonia is a colorless liquid, smelling of ammonia, and has a sharp burning, urinous taste. A perfectly saturated solution freezes between —100 and— 105 degs. Fahr., forming shining flexible needles. At —120 deg. Fahr. it solidifies to a gray gelatinous mass almost without smell.

Liquid ammonia possesses the property of dissolving many salts which are insoluble in

water. Its principal uses in photography are in the emulsion process for dry plates, and in the developing and intensifying of the image. It is also used in the positive process, when sensitized albumen paper is subjected to its fumes, and by this means increased sensitiveness and brilliancy are obtained. It dissolves silver chloride, and for this reason has been recommended as a fixing agent. It has only a slight solvent action on silver albuminate, however, and is therefore of no use wtih albumen paper. For plain salted paper it answers the purpose very well, and is said to be even superior to hypo. The bath recommended is made up of 4½ ounces to liquid ammonia in 10 of water.

In development, ammonia is used as the accelerator by rendering it alkaline and so enhancing its deoxidizing power, and it possesses the advantage over all other alkalies of giving greater brilliancy and vigor. With some makes of plates, however, ammonia will produce green fog. In published formula ammonia with specific gravity of .880 is generally recommended. It should, however, be tested by the accompanying table, as it is difficult to obtain with so low a specific gravity.

TABLE OF SPECIFIC GRAVITY OF AQUEOUS AMMONIA AT 60 DEG. FAHR.

Specific Gravity.	Percentage of Ammonia.	Specific Gravity.	Percentage of Ammonia.
0.990	2.31	0.930	18.64
0.980	4.80	0.920	21.75
0.970	7.31	0 910	24.99
0.960	9.91	0.900	28.33
0.950	12.74	0.890	31.75
0.940	15.63	0.880	35.60

Ammonia can be detected by its changing red litmus paper blue or by its smell, and also by its formation of a white precipitate with solutions of mercuric chloride. Solutions of ammonia are more stable the more dilute they are; therefore, it is advisable to add plenty of water and use proportionately.

AMMONIA ALUM.—See **Alum.**

AMMONIA FUMING.—See **Fuming.**

AMMONIA NITRATE PROCESS (an emulsion process described under **Emulsion**).—In this the boiling of the emulsion is dispensed with, and is substituted by a method of keeping it at a moderate temperature in a state of strong alkalinity with ammonia.

AMMONIO-CITRATE OF IRON.—See **Ferric Ammonium-Citrate.**

AMMONIO-NITRATE OF SILVER.—See **Silver Ammonio-Nitrate.**

AMMONIO-OXALATE OF IRON.—See **Ferric Ammonium-Oxalate.**

AMMONIUM ALUMINIUM SULPHATE.—See **Alum.**

AMMONIUM BICHROMATE (Formula, $(NH_4)_2Cr_2O_7$; molecular weight, 252. Synonym, *ammonium dichromate*).—Orange-colored monochromic crystals, prepared by neutralizing chromic acid with ammonia, and adding an equal part of chromic acid and evaporating. The crystals thus formed are freely soluble in water. Ammonium bichromate possesses the property of rendering certain organic bodies, such as albumen or gelatine, insoluble, when exposed to light. Potassium bichromate also possesses this property, and is usually preferred to ammonium bichromate in photo-mechanical printing, although the latter is more than twice as sensitive to light.

A mixture of ammonium bichromate and hypo has been recommended by Herr Babst as a reducing agent for positive prints, especially for aristotype pictures. The formula is 48 grains of hypo and 10 minims of a 10 per cent. solution of ammonium bichromate added to 1 ounce of water. After toning, and fixing, the prints, while still wet, are placed in the solution until the required reduction has taken place.

AMMONIUM BROMIDE (Formula, NH_4Br; molecular weight, 98) can be prepared by precipitating bromide of calcium by carbonate of ammonia, or by neutralizing hydrobromic acid with ammonia. Ammonium bromide is formed in fine white crystals, very soluble in water, but sparingly soluble in alcohol or ether. It is used in the manufacture of gelatino-bromide emulsions to form bromide of silver.

It was formerly also used in making collodion emulsions, but has been almost entirely supplanted by cadmium bromide owing to the latter's greater solubility in alcohol.

It is further employed as a restrainer in so-called alkaline development. Its action is stated to be the formation of a double salt with silver bromide; this salt having the power to greater resist the action of the developer.

AMMONIUM CARBONATE (Formula, $(NH_4)_2CO_3$; molecular weight, 342. Synonyms, *sal volatile, smelling salts*).—Ammonium carbonate appears to exist in three forms, the normal, the acid, and the sesqui-carbonate. Commercial ammonium carbonate is made by sublimation from chalk and sal ammoniac. It is bought in large translucent lumps having a strong odor of ammonia. On exposure to the air the ammonia escapes, and leaves a bicarbonate in the form of a white powder. This should be carefully scraped off, and the hard, unchanged centre portion only made use of. It is soluble in cold water; 100 parts at 55 deg. Fahr. dissolve 25 parts of ammonium carbonate; at 62 deg. 30 parts; at 89 deg. 37 parts; at 105 deg, 40 parts; and at 122 deg. 50 parts. Insoluble in alcohol.

Ammonium carbonate is used in photography in development to give density to the image. The action, is slow.

AMMONIUM CHLORIDE (Formula, NH_4Cl; molecular weight. 53.5. Synonyms, *muriate or hydrochlorate of ammonia, sal ammoniac*).—Ammonium chloride is a white, inodorous salt with a pungent taste. It occurs in small quantities in the neighborhood of volcanoes, but is usually manufactured by neutralizing ammoniacal gas liquor with hydrochloric acid, and after evaporating the liquid the residue is heated to sublimation, and the salt condensed in the form of a white crystalline mass.

Ammonium chloride dissolves readily in an equal part of boiling water, or in three parts of cold. Commercial kinds often contain iron. If a strong solution be made with boiling water and allowed to stand, the iron, should it contain any, will be precipitated as iron oxide in the form of a brown flocculent mass, which deposits itself at the bottom of the vessel.

The principal uses of ammonium chloride in photography are in the salting of albumenized paper and in emulsion making. In each case its mission is to form the chloride of silver, and for this purpose it is superior to sodium chloride because it contains more chlorine in proportion to its weight. It is also used in the preparation of a strong solution of mercuric chloride of intensification, as it causes much more to dissolve, by converting it into the more easily soluble double chloride of mercury.

AMMONIUM CITRATE.—A compound of citrate acid and ammonia. Three are known —the one usually employed for photographic purposes is triammonium citrate $C_6H_5(NH_4)_3O_7$. It occurs as a deliquescent solid and is principally employed as a restrainer with gelatino-chloride emulsion plates. With plates of this description it is possible by increasing the exposure and using this substance as a restrainer to get a large variety of tones ranging from black through brown, purple-brown, red-brown to red.

AMMONIUM HYPOSULPHITE (Formula, $NH_3S_2O_3+5H_2O$*).—Prepared according to Liesegang by mixing equal parts of hyposulphite of sodium and chloride of barium in solution, producing a precipitate of hyposulphite of barium. This is treated with carbonate or sulphate of ammonium, producing a solution of hyposulphite of ammonium. In commerce the salt is in the form of crystals which should be white and when dissolved leave no sediment. In the dry state these crystals will keep for a considerable length of time in yellow and well stoppered bottles. Ammonium hyposulphite has been recommended as a fixing agent and substitute for the sodium salt generally used. Spiller was the first to advocate its use in 1868, and later Dr. Liesegang and Monsieur Leon Lalane. The apparent advantage it possesses over sodium salt is its extreme solubility. The fixing bath can thus be prepared in the shortest time, and a very little washing is required to thoroughly eliminate it from the prints or negative films. The formula recommended is:

Water	1 litre
Ammonium hyposulphite	150 grammes
Chlorate of potash	10 grammes

The addition of the chlorate of potash has been recommended by Hernitta to obviate the ammoniacal vapor given off by many samples.

The high price charged for it in comparison to hyposulphite of soda is apparently the only reason why it has not entirely taken the place of the latter fixing agent.

AMMONIUM IODIDE (Formula, NH_4I; molecular weight, 145).—Colorless crystals, very soluble in water and alcohol, and very deliquescent when exposed to air; it should, therefore, be kept in closely stoppered bottles. It is also more or less decomposed by light, so should be kept in the dark. It is prepared by mixing equal volumes of hydriodic acid and ammonia, or by adding iodine to a saturated solution of hydrosulphate of ammonia until it begins to be colored. A precipitate of sulphur is formed, and the solution is now acid. Neutralize carefully with ammonia, and afterwards filter, evaporate and crystallize. If pure it should leave no residue on ignition.

Weissenberger's method of preparing it as required, and thus avoiding loss by deterioration, is a very simple one. Ten grammes of potassic iodide are dissolved in 20 c.c. of water,

*Rammelsberg's formula is $3(NH_4)_2S_2O_3+H_2O$.

and a solution of 4 grammes of ammonium of sulphate in 30 c.c. of water is added. Enough absolute alcohol is now added to bring the whole solution up to a volume of 218 c.c., when potassic sulphate separates out as an insoluble (in alcohol) precipitate, and iodide of ammonium remains in solution.

The equation of the reaction is:

$$2KI + (NH_4)_2SO_4 = 2NH_4I + K_2SO_4$$

This solution contains 4 per cent. of ammonium iodide. If one wishes now, for example, for the iodizing of a certain quantity of collodion to use 5 grammes of ammonium iodide, he takes 120 c.c. of this residual solution and dissolves it in the other chemicals necessary.

Ammonium iodide is used as an iodizer in the collodion on account of its solubility in alcohol and ether. It is, however, a very unstable composition, deliquesces rapidly, and becomes yellow by the separation of iodine and loss of ammonia.

AMMONIUM NITRATE (Formula, NH_4NO_3; molecular weight, 80).—This salt is prepared by neutralizing nitric acid with ammonia or ammonium carbonate. The solution is then evaporated and crystallized. Ammonium nitrate is not a stable salt, for it releases ammonia, and becomes acid with free acid. It is a solvent of oxide, and also carbonate of silver. When heated, nitrous oxide, or laughing gas, is evolved. If dissolved in an equal part of water the temperature of the latter is lowered from 40 degs. to 4 degs., and it is therefore used as a freezing mixture.

AMMONIUM OXALATE (Formula, $(NH_4)_2C_2O_4$; molecular weight, 124).—Formed by the neutralization of oxalic acid with ammonium carbonate. It occurs in fine needles, permanent in air and soluble in twenty times its weight of water. It is employed in the making of ferric ammonium oxalate used in the platinotype process.

AMMONIUM SULPHIDE (Formula, $(NH_4)HS$; molecular weight, 51. Synonym, *sulphuret of ammonia*).—This solution is obtained by passing sulphuretted hydrogen through a solution of ammonia at an ordinary temperature until absorption ceases, and the liquids are mixed. It should be colorless and kept in a well stoppered bottle, away from the dark-room. It has a disgusting smell of ammonia and rotten eggs, and its fumes are liable to upset other operations Exposed to light, it quickly becomes yellow and changes into ammonium sulphydrate, NH_4HS. It is used in photography for intensifying negatives, and for precipitating silver solutions. It is very soluble in water and alcohol. Ammonium sulphide is also a good test for iron, forming a black precipitate of iron sulphide.

AMMONIUM SULPHOCYANATE (Formula, NH_4CNS; molecular weight, 76. Synonym *sulphocyanide of ammonium*).—Obtained by mixing hydrocyanic acid with polysulphide of ammonium (a solution of sulphur in ammonium sulphydrate) and separating the sulphocyanate thus formed by water or alcohol. It crystallizes in colorless deliquescent tablets, very soluble in water and alcohol. It is used in a large number of the toning and combined toning and fixing baths recommended for gelatino-chloride printing-out papers. Ammonium sulphocyanate can also be used as a fixing agent instead of hypo, but it is much inferior, and has a tendency to soften the gelatine. It has also been recommended* as an addition to the uranium toning bath as a solvent of the ferrocyanide of silver and potassium, said to be formed in the toning operation.

AMORPHOUS.—A term applied in chemistry to substances which have no definable determinate or definite form.

AMPHITYPE.—An application of the calotype process invented by Sir John Herschel, in which light produces either a negative or a positive. It is thus described: A sheet of paper is prepared with a solution either of ferro-tartrate, or ferro-citrate of protoxide, or peroxide of mercury, and then with a solution of ammonia tartrate, or ammonia citrate of iron, the latter solution being in excess. On exposure to light in the camera a negative is produced of more or less vigor, and of a very rich brown tint, if the paper contains a salt of lead. It gradually fades in the dark, but may be restored as a black positive by immersing it in a solution of nitrate of mercury and ironing it with a very hot iron.

AMYL ACETATE (Formula, $C_5H_{11}(C_2H_3)O_2$; molecular weight, 132. Synonym, *essence of gargonelle pears*).—Made from fusel oil, 1 part; potassium acetate (dry), 2 parts; concentrated sulphuric acid, 1 part; distilled with the usual precautions from a glass retort into a cool receiver. The distillate is purified by washing with very dilute solution of potassa, and redistilling it from fused calcium chloride. It is a limpid and colorless liquid, insoluble in water, but soluble in alcohol. It boils at 137 deg. Fahr., and burns with a brilliant flame, rich and refrangible rays. See **Amyl Acetate Lamp.** It has an extremely pleasant odor of ripe pears which soon becomes nauseous and produces headache. It is sometimes employed as a solvent of gun-cotton to form a

* By Prof. R. Namias in *Revista Scientifico-artistica de Fotografia.*

collodion. In some respects it is superior to alcohol and ether as it gives a structureless film. Some samples of pyroxyline are almost insoluble in alcohol and ether, but perfectly soluble in amyl acetate.

AMYL ACETATE LAMP.—A lamp devised by Hefner Altenek giving a monochromatic light. It was adopted as a standard light for photographic purposes by the Paris Congress, held in 1881.

Amyl acetate is burnt in it with a cotton wick, the internal diameter of the wick tube should be 5 mm., and the height of the flame 25 mm. 1 cm. from the axis of the flame is placed a thin metal chimney, in which is a small aperture 4 mm. broad and 30 mm. long, and fhis can be shifted up and down so as to bring it opposite the brightest part of the flame. The amyl acetate should have a constant boiling point of 138 deg. C., and be free from acetic acid and water. The special compostion of the flame is similar to that of a candle, and compared to the English standard candle, setting the amyl-acetate lamp as = 1, the candle = 1.140. All metallic parts of the lamp should be made of fine silver, as the fluid so corrodes brass and other metals as to render them useless.*

AMYLOSE.—See **Starch.**

AMYLOTYPE.—A photograph produced by the action of light on vegetable matter. See **Anthotype.**

ANACHROMATIC.—A term applied to a corrector for achromatism (*q. v.*).

ANACLASTIC.—Pertaining to the refraction of light.

ANAGLYPH.—A stereoscopic picture, the invention of Ducos du Hauron, consisting of two images printed one upon the other in two colors—one red and the other blue. The images are not printed on the same place, but overlap about one-quarter of an inch. In Fig. 26, the dotted lines show the position of one of the images in its relation to the other. The effect, of course, is to give an unsightly looking picture, looking like a chromo that had fallen out of register in printing.

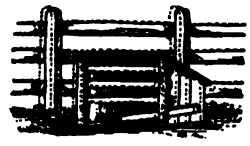


FIG. 26.—ANAGLYPH.

On viewing this double image through a pair of eye-glasses, one blue and the other red, the image is seen stereoscopically. The explanation is, of course, that the blue glass kills the blue image, the red one being visible with one eye, and the red glass kills the red image and allows the blue one only to be seen with the other eye. The two images differ not only in color, but also in the same manner as two images made with a stereoscopic camera. On reversing the glasses the opposite effect, or pseudoscopic vision, is the result.

The same idea has already been carried out in a manner enabling a number of persons to view stereoscopically images projected on the screen with a lantern. All that is necessary is to make two slides from a stereoscopic negative, one with a red image and the other with a blue, throw them upon the screen together, and view through the colored spectacles. Probably the best method of producing the lantern slides in the two colors would be by the carbon process, using suitably prepared tissues.

ANAGLYPHOSCOPE.—An arrangement for viewing anaglyphs (*q. v.*) to obtain a stereoscopic effect. It consists of two pieces of glass or other transparent material, one colored red and the other blue, usually made up in the form of eye-glasses or spectacles. On viewing the anaglyph through these glasses only one picture is visible to each eye, and a stereoscopic effect is thus obtained.

ANALYSIS.—In chemistry, the examination of bodies with a view of ascertaining of what substances they are composed and in what proportions these substances are contained. The former is termed qualitative and the latter quantitative analysis. There are various methods of analyzing or separating the particles of a chemical compound. These may be classified into the following: Blowpipe, qualitative, gravimetrical, and volumetric, and the proximate and ultimate analysis of organic bodies. Having isolated these constituents we next proceed to put them together again to reproduce the original substance. This is called synthesis, and is more clearly explained under **Chemistry.**

The following information is likely to be of use to photographers wishing to analyze any substance or to detect any impurities:

The substance to be analyzed is dissolved in a test tube. If not soluble in water, hot or cold; then in hydrochloric acid or in aqua regia, and if insoluble in these it is fused with sodium carbonate. The solution thus obtained is termed the *original solution.* To this add a few drops of hydrochloric acid. If a white precipitate is formed it is either silver chloride, mercurous chloride, or lead chloride, indicating the presence of these metals. Filter, and pass sulphuretted hydrogen gas through the filtrate. If the precipitate turns black, lead, copper, mercury, or bismuth is present. A yellow precipitate indicates cadmium arsenic or tin. A brown precipitate shows tin (in another form), and an orange color denotes the presence of antimony.

* E. J. Wall's Dictionary of Photography.

Filter again, and boil the filtrate in order to expel the sulphuretted hydrogen. Now add a few drops of nitric acid, boil to oxidize the iron, and add chloride of ammonium and ammonia. A red precipitate shows the presence of iron; if of a bluish-green color, chronium. A white precipitate indicates aluminium, or phosphates, borates and oxalates.

Again filter, and add ammonium sulphide to the filtrate. If it turns black, cobalt or nickel; if pink, turning brown afterward, manganese is present, or, if white, zinc.

Filter, and add to the filtrate ammonium carbonate. A white precipitate shows calcium, barium or strontium. Filter and divide the filtrate into two equal parts. To one add a small quantity of sodium phosphate, and if a white precipitate is formed, it proves the presence of magnesium. The other portion is evaporated to a dry powder, heated to drive off the ammoniacal salts, and tested for potash and soda.

Take another portion of the original solution and test for ammoniacal salts. Add to it caustic potash. This will liberate the ammonia, which is easily recognized by its smell and its action upon red litmus or turmeric paper.

Arsenic, antimony, and tin sulphides are soluble in ammonium sulphide, and can be reprecipitated by hydrochloric acid.

To test acids, observe the following: Carbonic, hydrosulphuric and hydrocyanic acids are liberated by stronger acids with effervescence. Carbonic, arsenious arsenic, chromic, boracic, phosphoric, oxalic, hydrofluoric, and sillicic acid, give from a neutral solution a white precipitate, insoluble in acids; tartaric and citric acids may be easily recognized by the precipitate charring when heated, and giving out fumes of a peculiar odor. If calcium chloride be added to phosphoric acid, a white precipitate is formed, which is soluble in acetic acid. Oxalic and hydrofluoric also give a white precipitate with calcium chloride, but it is insoluble in acetic acid.

Silver nitrate gives a black precipitate with hydrosulphuric acid, a red precipitate with chromic and arsenic acids, a white precipitate with boracic and oxalic acids, a yellow precipitate with arseneous, phosphoric and sillicic acid. All these precipitates can be dissolved in nitric acid. Hydrochloric, hydrocyanic and hydriodic acids, however, give a precipitate insoluble in nitric acid.

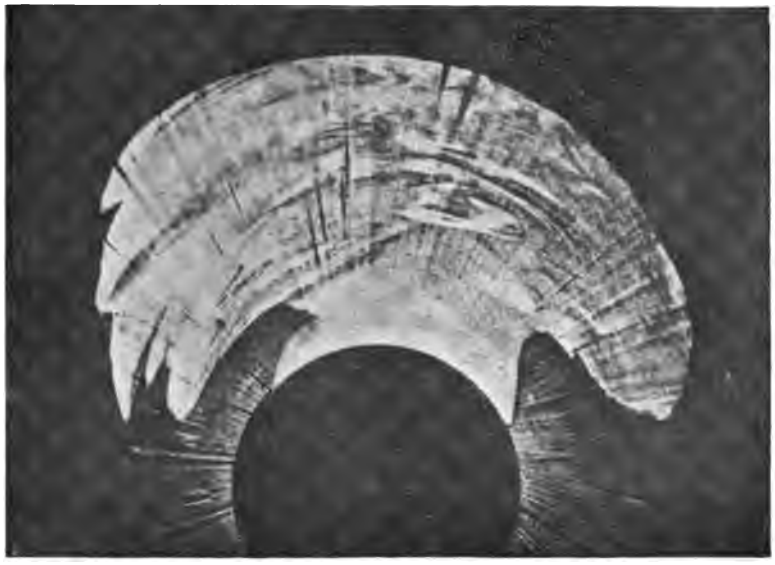


FIG. 27.—A PHOTOANAMORPHOSIS.

Acetic acid and sulphuric acid give with ferric chloride a red color. If ferric chloride be added to gallic and tannic acids, a black precipitate is the result.

A doubtful substance should be treated in as many different ways as possible, and it is not difficult to prove all the component parts, if each be tested for by the different methods given. With the description of each chemical is given, where possible, one or more methods of testing and proving existence of adulterations.

ANAMORPHOSOPE. — An optical toy, consisting usually of a vertical cylindrical mirror in which a distorted drawing or photograph termed an anamorphosis is viewed correctly. See **Anamorphosis.**

ANAMORPHOSIS.—The name anamorphosis has been given to two sorts of pictures, distorted according to a certain law, and which are of such a grotesque appearance that it is often impossible to recognize the subject of them; while viewed with a proper apparatus, they appear regular and take their normal appearance. One sort is designed to be viewed by reflection, the other sort is reconstituted by means of a special apparatus and rotatory motion. Until recently these pictures have been drawn approximately from the reflection of the object as seen in a convex mirror, whose position was indicated on the drawing, and which restored it to its real form. M. Fenant conceived the idea of employing photography for obtaining these pictures. Fig. 27 reproduces a photoanamorphosis from a negative by M. Frenant. If a cylindrical mirror be placed upon the black circle shown in the drawing, the photograph will appear in its original form. Our illustration gives a portrait, although the features are hardly recognizable. Indeed, a great deal of fun can be had by making portraits of friends and relatives, and trying to recognize them without the use of the cylindrical mirror. Similar pictures may be obtained by photo-

graphing the drawing or subject reflected in a cylindrical concave mirror placed perpendicular to the drawing or in front of the subject. The second sort of anamorphosis is produced by the distortion of the picture in the sense of one of its dimensions. To reconstitute it, it is caused to rotate rapidly, at the same time that a disk, perforated with a slit, through which the picture is observed, is rotated in front of it at a slightly different speed.

The apparatus invented by M. A. Linde for producing the anamorphosis is shown in Figs. 28 and 29. G is a camera provided with a revolving plate-holder, T; H is a revolving disk, whose movement is made to bear a certain relation to that of the plate-holder by means of the band, f, and pulleys, D, D. The whole is set in operation by a clock-work and the band, F. A is the axis of the camera, B that of the plate-holder, and C, that of the revolving disk.

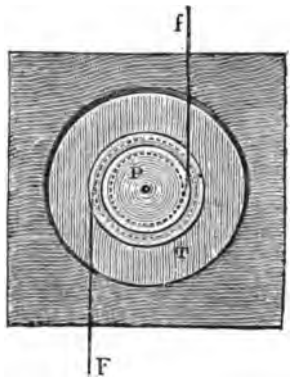


FIG. 28.

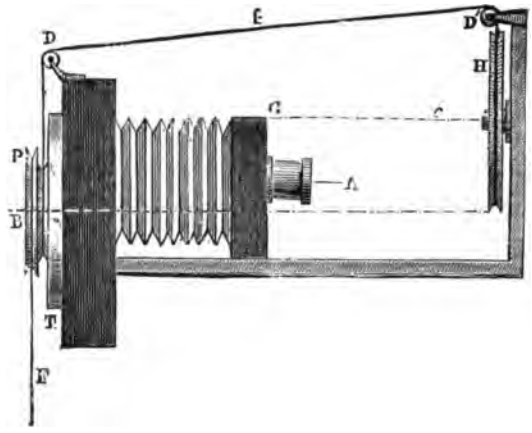


FIG. 29.

On this disk is fixed the picture of which it is desired to make an anamorphosis. The relative motions are so regulated that when the plate-holder has made a complete revolution, the disk has turned through an angle of 60 to 80 degrees in the opposite direction. Between the plate-holder and the objective is a diaphragm pierced with a slit 10 m.m. wide. The action of the light on the plate takes place through this slit. The negative obtained, prints are made on salted paper and rendered transparent; they may then be viewed in an ordinary apparatus such as is used for reconstituting the ordinary anamorphosis of this class.

ANAPLANATIC.—Same as **Aplanatic** (*q. v.*).

ANASCOPE.—An optical arrangement permitting one to view the camera image the right side up; that is to say, not inverted.

ANASTIGMATIC.—This term has been applied to lenses corrected for astigmatism. The term, however, is a pleonasm. *Stigmate* means, literally, a focus, a point where light rays converge to. *A-stigmate* means a failure to concentrate at one point. *An-astigmate* is where this failure is corrected. Consequently the lens is *stigmatic*, a term that would appear to be simple and more correct. *Antastigmatic*, or opposed to astigmatism, is also employed for the same meaning.

ANGLE.—Literally the opening between two lines which meet one another. Optics have angles of aperture, of incidence, of reflection, of refraction, of deviation, and of polarization. See under these respective headings.

The width of the angle of a lens is determined by the relation of the focal length to the image given, and lenses are thus termed narrow, mid or wide angle lenses, accordingly. To determine the width of angle of a lens, divide the base line of the plate by the equivalent focus of the lens (see **Focus**). Having found this out, it will be easy to determine the angle of view included upon the plate by reference to the following table by Clarence E. Woodman:

If the Quotient is	The Angle included is	If the Quotient is	The Angle included is	If the Quotient is	The Angle included is	If the Quotient is	The Angle included is
.5	28 degrees	.808	44 degrees	1 155	60 degrees	1.56	76 degrees
.517	29 "	.828	45 "	1.178	61 "	1.59	77 "
.536	30 "	.849	46 "	1.2	62 "	1.62	78 "
.555	31 "	.87	47 "	1.225	63 "	1.649	79 "
.573	32 "	.89	48 "	1.25	64 "	1.678	80 "
.592	33 "	.911	49 "	1.274	65 "	1.7	81 "
.611	34 "	.933	50 "	1.3	66 "	1.739	82 "
.631	35 "	.974	51 "	1.32	67 "	1.769	83 "
.65	36 "	.971	52 "	1.36	68 "	1.8	84 "
.67	37 "	1.0	53 "	1.375	69 "	1.833	85 "
.689	38 "	1.02	54 "	1.4	70 "	1.865	86 "
.708	39 "	1.041	55 "	1.427	71 "	1.898	87 "
.728	40 "	1.063	56 "	1.45	72 "	1.931	88 "
.748	41 "	1.086	57 "	1.48	73 "	1.965	89 "
.768	42 "	1.108	58 "	1.5	74 "	2.	90 "
.788	43 "	1 132	59 "	1.53	75 "		

Let us take, for example, a lens with an equivalent focus of 15 inches and we require to know the angle of view included upon a 10 x 12 plate. The base-line here is 12 inches. Twelve divided by 15, the equivalent focus, gives 1.25, corresponding, as shown in the above table, to 64 degrees.

The following method of measuring the angle of view included by a lens is given by Burton:

Focus the sun on the center of the plate some time when it is pretty near the horizon. The smallest top is inserted, and the camera is slowly swiveled till the image of the sun disappears. The spot where it was last seen is marked, and the camera is then turned in the opposite direction, and the spot where the sun was last seen is again marked. The distance of the two marks is the diameter of the circle covered. To find the angle the following construction is made: A line (AB) (Fig. 30) is drawn equal to the focal length of the lens. At B a line BD is erected perpendicular to AB. BD and BC are each made equal to the radius of the circle. AC and AD are then joined. The angle CAD is then measured with a protractor or otherwise, and is the angle of the lens, and the diagonal of the largest plate that can be used. To discover if the lens will cover any given size of plate, the circle is drawn out on the paper, and it is found by actual experiment whether or not the plate will come within it. For example, the diameter of the circle is 16 inches. If it is desired to find if a plate 12 x 10 inches will come within it, the plate is laid on the circle, and it is found that it just comes within it. With a larger plate the corners project.

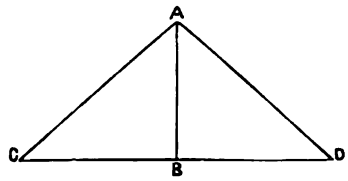


FIG. 30.

It is not advisable to try to make a lens cover too large a size of plate, as the result will be unpleasant dark corners. In fact, no little advantage is gained by using a lens for a size smaller than that for which it is intended—for instance, a 5 x 4 lens for a quarter-plate.

ANGLE, MID.—A term applied to lenses of medium type having the focal length intermediate between a "wide angle" and a "long focus" lens.

ANGLE, WIDE.—"Wide angle" is a term applied to certain forms of lenses so constructed that they will embrace a larger amount of view than the ordinary or narrow angle lens by having their focus very short in comparison to the base line of the plate. Figs. 31 and 32 will serve to show the meaning of this more clearly.

Wide-angle lenses are most useful in photographing buildings or other objects when we require to include a large amount in the picture, and which with an ordinary lens it is impossible, owing to the inability to place the camera at a sufficient distance.

The angle of view of the eye does not exceed 50 degrees. A lens with an angle of 40 degrees gives the most artistically truthful picture, and except for special purposes already mentioned, no lens should be used with a greater angle than 50 degrees. The result of using wide-angle lenses is pictures with painfully exaggerated perspective, the objects in the foreground appearing large and out of proportion, while the more distant ones are dwarfed and appear at an exaggerated distance.* This power of making exaggerated photographs has been largely made use of for advertising purposes. Photographs taken by wide-angle lenses can be seen every day advertising houses for sale, illustrating the saloon accommodation of steamboats, etc., in every case deceiving the eye of the observer as to the actual size of the object represented.

Wide-angle lenses, however, possess many drawbacks. They require a small diaphragm, in order to obtain sharp definition, by the use of which the light is considerably reduced and the exposure necessarily increased in proportion, so that they are at best but slow workers.

They also give unequal definition. If we take two equally bright and equidistant objects, the image of one falling on the margin, and that of the other upon the center of the plate, the area occupied by the first image will be greater than that occupied by the second, and consequently the marginal illumination will be less; the diminution of light from both these causes increases with the angle of view beyond 40 degrees. At this angle the extreme margins receive 80 per cent. of the light falling upon the center at 50 degrees but 70 per cent., at 60 degrees, only 55 per cent., and at 70 degrees no more than 45 per cent. Therefore, it will be seen that with the increase of angle we get an increase of this defect. Dallmeyer makes a lens with an angle of 100 degrees. A lens of this description, however, would only be useful for certain purposes. Wide-angle lenses give distortion, particularly noticeable in photographing buildings. The swing back of the camera can be used to remedy it, but with it a small stop must also be added. See **Lens**.

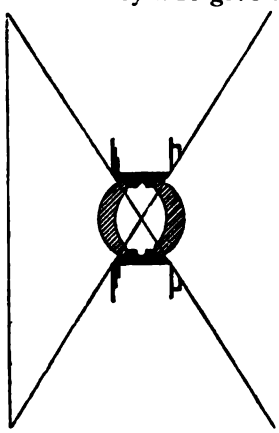


FIG. 31.—EFFECT OF WIDE ANGLE LENS.

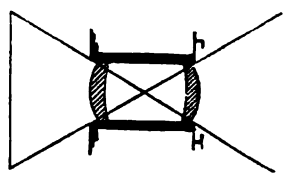


FIG. 32. — EFFECT OF NARROW ANGLE LENS.

* It should be noted that this distortion is only apparent; if a picture be taken with a wide angle lens of say 5 inches focus, it would appear in correct perspective if viewed at a distance of 5 inches from the eye. But this is, of course, never done by the ordinary observer.

ANGLOL.—A trade term for eikonogen (*q.v.*)

ANGULAR APERTURE.—The relation of the working diameter of a lens to its focal length. The wider the angular aperture the less the depth of focus and covering power of the lens. Drawing two imaginary lines from the two extremities of the landscape through the center of the lens or combination to the corresponding extremities of the picture, two isosceles triangles are formed with their vertical angle at the center. This angle or opening of the two outside rays constitutes what is termed the angular aperture.

ANHYDRIDES.—An anhydride, or an anhydrous acid, is a chemical substance, formed by the substitution of an acid radical for the whole of the hydrogen in one or two molecules of water.

ANHYDROUS.—Having no water in its composition. When the water is replaced by a base, or is otherwise entirely removed, the substance is anhydrous.

ANHYDROUS NITROUS ACID.—See **Nitrous Anhydrides.**

ANILINE.—(C_6H_7N; molecular weight, 93. Synonyms, *phenylamine, amido benzine*).—Prepared by reducing benzine with iron filings, in presence of a small quantity of hydrochloric or acetic acid, and separating the aniline formed by distillation. Aniline is a thin, colorless oil, of a burning taste and aromatic flavor, sparingly soluble in water (3 in 100) but readily soluble in alcohol, ether and benzene, turns red in the air, and coagulates albumen. With chromic acid it gives a deep green or bluish-black color; upon this property the aniline process is based, *q.v.* It is also the base of many of the dyes used in orthochromatic photography.

ANILINE DEVELOPMENT.—See **Aniline Process.**

ANILINE DYES.—There are a large number of aniline dyes. The principal ones are: Aniline black, aniline blue, aurantina, aurine, chrysodine, coralline, cyanine, eosine blue, eosine yellow, erythrosine, fluorescine, fuchsine, gentian blue, gentian violet, iodine green, malachite green, methyline blue, methyl violet, methyl green, methyl orange, napthaline, nigrosine, phenylene blue, purpurine, rosaniline, saffranine, tropæoline, uranine, and vesuvine. Many of these are used as sensitizers in orthochromatic photography. The dry-plate, previous to exposure, is either bathed in a weak solution of the dye, or the latter has been made up in the emulsion with which the plate is coated. Photographs obtained in this manner are in many cases more truthfully related in light and shade to nature. See **Orthochromatic Photography.**

ANILINE PROCESS.—A process based on the oxidation of aniline by chromic acid, and used for copying tracings, maps, etc., invented by Willis. Paper is sensitized with a solution consisting of potassium dichromate 1 part, phosphoric acid (sp. gr. 1.124) 8 to 10 parts, and water 10 to 12 parts. This solution is brushed over best Saxe paper with a stiff brush, about one inch wide, and the paper hung up to dry. This operation must be performed in the dark-room, as the paper is extremely sensitive. The prepared paper is then exposed under a tracing to direct sunlight. The correctness of the exposure is an important matter, therefore an actinometer should be used. If the paper is correctly prepared, it should be of a yellow color, and after exposure a faint yellow picture will appear on a greenish ground. The picture is removed from the frame in the dark-room, and developed by pinning to the lid of a fuming-box, provided with a sheet of glass, upon which is placed some pieces of blotting paper, saturated with a solution of aniline oil 1 part, and benzine 10 parts. There it must remain for about half an hour, and if properly developed, the result will be dark brown lines on a grayish ground. If it be too faint, however, the development must be continued for several hours, until completed; it is then washed for some time in several changes of water, and dried. It gives a positive impression from a positive.

ANIMAL CHARCOAL.—See **Charcoal.**

ANIMAL PHOTOGRAPHY.—To photograph animals successfully great patience is required. Mr. Charles Reid, who has made quite a study of this branch of the art, says:* "No hard and fast rules can be laid down for taking animals to advantage, but it may safely be affirmed that without a lively sympathy with the lower creation no one need approach its members with a camera unless he deliberately chooses to be bored. On the part of such as would derive the pleasure from this pursuit that it is capable of affording, there must be a readiness to adapt oneself to varying circumstances combined with a knowledge of animals and their ways. Their habits and temperaments will be found to differ widely, and then they have to be dealt with under varying conditions of light—sometimes in most unfavorable localities—and in all sorts of weather. In order to tackle them successively one must be in no uncertain mood. Whatever is decided on must be accomplished by some means or other. Those of a timid disposition must be gently dealt with, the unruly have to be cowed, the slovenly must be roused, shy subjects have to be allowed sufficient time—perhaps necessitating repeated

* The Photographic Times, November, 1895.

visits for them to get familiar with the camera, and so on, according to the results desired." Some knowledge of the haunts and habits of animals is essential in order to make successful pictures. Take, for instance, the study of Ottomar Anschütz (Fig. 33). Although the photograph was made in a cage, the artist has supplied a background which gives us in a most realistic manner a picture of the lion taken apparently in the open plains of Africa. Another illustration is given to show what can be done in this class of portraiture.

FIG. 33.—ANIMAL STUDY. BY OTTOMAR ANSCHÜTZ.

ANNATTO.—A dye used in preparing orthochromatic screens.

ANOMALOUS DISPERSION.—See **Dispersion.**

ANTACID.—Any substance, such as potash, soda, lime, etc., which counteracts acidity or neutralizes it.

ANTHOTYPE.—A process proposed by Sir John Herschel, in which paper was saturated with the green juice of the leaves of the young cereals, and used in the same way as chloride of silver paper to copy pictures on. The uncovered parts are speedily bleached under the influence of the luminous rays, and a most delicate and beautiful positive copy is produced from a positive original. Alcohol solutions of various resins, the juice of the rose and violet, tincture of turmeric, and many other vegetable coloring matters may be used in the same way. They are not permanent, however.

FIG. 34.—ANIMAL STUDY. BY H. DIXON.

ANTHRAKOTYPE.—A term applied to a dusting-on process, in which gelatine is used.* See **Dusting-on Process.**

ANTHROPHOTOSCOPE.—An instrument for obtaining some curious photographic effects. It is thus described by Schnauss†: Photographic portraits are cut free from the background very neatly and fastened upright on a wheel, which revolves with a background on a different plane (say at an angle of 10 to 12 deg.) from the figure itself. The table is then placed in a box or case. To obtain the proper effect, then, the pictures are viewed through a large magnifying glass of long focus, minute fractions of an inch being converted into apparent distances.

The figures may be variously grouped, and the backgrounds changed at will in the following manner: A variety of landscape views or other scenery is arranged around the marginal portion of a large flat wheel, say 2 feet in diameter, that part of the wheel being beveled or sloped back, so as to form an angle of 10 or 12 degs., with the general face of the wheel, this beveled space being, say, 4 inches wide from the periphery toward the centre. This wheel is placed on a horizontal axis. Close in front of this beveled wheel another thin wheel, say 8 inches less diameter than the first, is placed, but revolving independently round the same axis, the periphery of the smaller wheel just reaching the beveled portion of the larger. In front of this again other thin wheels, all parallel to the first, are placed, revolving independently of each other, but round the same common axis, each wheel in succession being so much smaller than the one behind it that a line touching their peripheries would make nearly the same angle with the vertical face of the wheel as the plane of the background on the larger wheel. In the edges or peripheries of these small thin wheels narrow grooves or slits are cut, vertical and parallel to the sides of the wheel, for slipping in and holding the vignetted likeness.

This being the mechanical arrangement, the full-length pictures are attached immediately to the inclined background on the large wheel (being held divergent to its plane by means of wedges) and the vignettes are held in their positions, diverging from the background, by slipping the lower edge into the vertical grooves formed in the edges of the smaller wheels, the relative positions and angles of background and likeness being the same as for the stationary pictures. These wheels being suspended inside a box, a large magnifying glass of, say, 4 inches diameter, and 12 to 14 inches focal length, is placed in the front side of the box, opposite that point where the figures become upright in revolving. The light may be admitted through a tinted glass. A movement of either wheel brings different figures in juxtaposition, and a movement of the large wheel backs the picture with a different landscape. To exhibit the most beautiful effects with this mode of arrangement there should be several of the smaller wheels graduated down as we approach the front in the portion before indicated.

ANTICHLOR.—Any substance that will neutralize chlorine. Sodium hyposulphite acts as a cheap and efficient antichlor.

ANTIDOTES.—A list of antidotes to the various poisonous chemicals used in photography, will be found with *poisons.*

ANTI-HALATION PLATES.—Photographic dry plates so prepared that the effect of halation produced by the reflection from the glass support is avoided. The two principal methods adopted are by coating the glass with two or more films of emulsion, the undermost being of very low sensitiveness, and by preparing the back of the plate with a non-actinic coloring matter which renders the reflected rays inactinic. See **Halation.**

ANTIMONY SULPHIDE (Formula, Sb_2S_3).—A black powderish substance, mixed with sulphur, potassium chlorate and powdered magnesium; it forms a compound suitable for making a flash light to be used for photographing at night.

ANTIPHOTOGENIC.—Opposed to photo-chemical action.

ANTIPLANATIC.—This term is sometimes used instead of **Aplanatic,** *q. v.*

ANTI-PYR.—A trade term for a hardening solution, the active ingredient of which is formic aldehyd. It is used for rendering gelatine films insoluble. See **Formic Aldehyd.**

ANTI-RUST VARNISH.—See **Varnishes.**

ANTISEPTIC.—A substance which has the effect of counteracting the tendency to putrefaction. Antiseptics destroy the activity of the infectious matter, in many cases without altering the composition of the body. The principal ones are carbolic acid, alcohol, essence of cloves, sulphurous acid, sodium chloride, and corrosive sublimate; alum, alcohol, carbolic acid, chloral, or zinc salts in small quantities will act as an antiseptic, and prevent the putrefaction of gelatine; as will also glycerine in large quantities. According to a French chemist,

* "*Anthrakotypie.*" Pizzighelli; *Photo Correspondence:* also Vogel's "Progress of Photography."
† "Photographischer Zeitvertreib."

cinnamon is a most powerful antiseptic and superior to essence of cloves, which is very largely used in preserving photographic pastes, etc.

APERTOMETER.—An instrument for measuring the apertures of an objective.

APERTURE—The clear space which receives the light of the object. The diameter of of the opening of the lens exclusive of its setting. If a diaphragm be used, the diameter of its opening.

The *working aperture* of a lens is that part of it which is actually used to obtain the image upon the screen or sensitive plate. The diameter of the lens or diaphragm opening is often taken as the working aperture. In doublet lenses, however, the diaphragm aperture does not accurately determine the working aperture of the lens. To obtain the correct value of each stop, draw out the camera to the equivalent focus. The glass of the focusing screen is then removed and replaced by a piece of opaque paper or cardboard, in the centre of which a small pinhole has been punctured. A candle is next brought near to the hole in the card, and upon looking at the front combination of the lens we shall see, if we place a stop in the lens, that only a small disc of the lens is illuminated by the rays of light from the candle coming through the pinhole; and the diameter of this disc is the working aperture of the lens when used with that particular diaphragm. Each one should be calculated in this manner and marked. If any difficulty is found in measuring the illuminated portion of the lens, by breathing on the glass the operation is facilitated.

APHANASCOPY.—See **Stereoscopy.**

APHENGOSCOPE.—A megascope or optical lantern for projecting images of opaque objects. See **Megascope.**

APLANAT.—A name given to a lens by Steinheil. It is constructed of two kinds of flint glass, a light and a dense kind. By this means achromatism is effected in the same manner as by using flint and crown glass, with which the majority of achromatic lenses are now made. See **Achromatic.**

APLANATIC.—Synonym—*aplanetic*.—A lens is said to be aplanatic when it is corrected for spherical aberration, as far as practicable, by combining two or more lenses of different form. Theoretically, it is impossible to entirely correct this aberration, but the term means, practically, that the lens will give a reasonably sharp definition with its full aperture.* See **Aberration.**

APOCHROMATIC.—A term that has recently been applied to a special class of lenses made with a glass known as Jena glass, from the town in Germany where it is manufactured. Practically, the term denotes that the secondary spectrum has been eliminated or nearly so, and that the lens is, therefore, more accurately corrected for chromatic aberration, *q. v.*

APOTHECARIES' WEIGHT:—See **Weights and Measures.**

APPARATUS.—The various materials and instruments used in photography, and which are severally described under the various headings.

APRICATION.—Exposure in sunshine.

AQUA FORTIS,—An old name for nitric acid. Still used, however.

AQUA REGIA.—A liquid consisting of nitric acid and hydrochloric acid. It possesses the property of dissolving the king of metals (gold), hence the name "regia," or "royal." In reality, however, it is only the chlorine that attacks the gold. See **Nitrohydrochloric Acid.**

AQUA VITÆ.—See **Alcohol.**

AQUEOUS.—Made by the addition of water.

AQUEOUS AMMONIA.——Liquid ammonia. See **Ammonia.**

AQUIFORM.—Liquid; resembling water.

ARABIC, GUM.—See **Gums.**

ARCHITECTURAL PHOTOGRAPHY.—In photographing architecture (where parallel, vertical, and horizontal lines are included), it is essential that a lens be used that gives the least amount of distortion. It is clear, then, that a landscape or single combination lens is unsuited for the purpose. The best results are obtained with a rectilinear lens having a focal length a little shorter than the base-line of the plate. Thus, for a 15 x 12 picture, a lens of 14 inch focus, the image would include an angle of 50 degrees. For special purposes, however, such as the photographing of a building in a confined situation, it is necessary to use a wide-angle rectilinear, but for reasons mentioned under **Wide Angle** this kind of lens should never be used unless absolutely necessary.

* The term aplanatic was first employed by a Scotch savant (Dr. Blair), who, in 1701, made use of it to signify certain points of superiority in lenses which he had constructed. Its application since that time has been narrowed down to signify freedom from spherical, in contradistinction to chromatic, aberration.—J. TRAILL TAYLOR.

The camera should be placed perfectly level, and for this purpose a spirit level fitted into the camera is very useful. When it is necessary to include the entire building, raise the sliding front of the camera. If this is insufficient, try to get on to higher ground to take the view. If this is impossible, as a last resort, to be employed only in such a case, tilt the camera. If this is done, the swing-back must be used to restore parallelism between the planes of the object and the margin lines of the focusing screen. A small stop must then be used, otherwise an imperfectly sharp image will be the result.

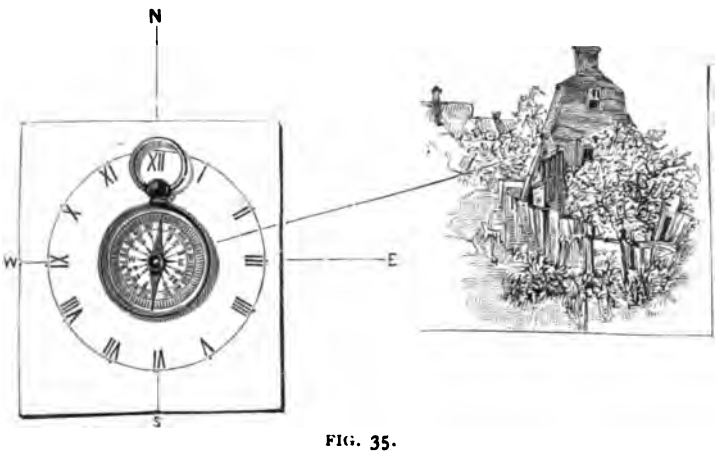


FIG. 35.

The photographing of exteriors should rarely be attempted without sunlight striking at an angle to give shadows. Choose a time when, on taking up position with the camera, the sun is shining over the right or left shoulder. If directly behind, flat pictures are inevitable.

An ingenious contrivance for finding at what time the sun will shine upon a building from a given direction may be made from a compass and watch-dial, thus :* Place the compass over the face of the watch in such a way that the magnetic needle will point toward the numeral XII. (see Fig. 35). Then imagine a straight line passing from the centre of the dial to the centre of the building. The numeral on the dial which this line cuts will indicate the required time.

The exposure varies, of course, with the actinicity of the light and with the distance from the object. The time required naturally increases the nearer we approach. The color of the building must also be taken into consideration and is very deceptive. It is better to err on the side of over-exposure, as the masonry, especially if yellow with age, does not reflect so much light as is imagined. For photographing the interiors of buildings, see **Interiors.**

AREA SYSTEM.—A system, invented by Mr. Geo. Smith, of calculating relative exposures with various stops and lenses. It is based upon the principles, firstly, that if a given stop with a given lens requires an exposure of one second, then a stop of half the diameter would necessitate four times the exposure; and, secondly, that if a given stop with a given lens requires an exposure of one second, a lens of double the focus, with that stop, would require four times the exposure, and with one three times the focus, a nine-fold exposure is required approximately.

AREOMETER.—An instrument designated to measure the specific gravity of liquids. See **Specific Gravity.**

AREOMETRY.—The act or process of measuring the specific gravity of liquids.

ARGENTIC.—Pertaining or relating to silver; composed wholly or partly of silver, or obtained from silver.

ARGENTIC OPALS.—See **Opals.**

ARGENTIC SALTS.—Silver salts, such as *argentic chloride, argentic nitrate*, etc. See **Silver Chloride, Silver Nitrate.**

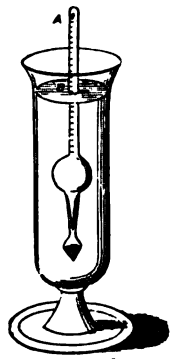


FIG. 36.
ARGENTOMETER.

ARGENTOMETER.—An instrument for measuring the quantity of silver nitrate contained in an aqueous solution by its specific gravity. It consists of a simple hydrometer marked with a scale showing the number of grains of silver nitrate per ounce of solution. It is understood, of course, that the latter be perfectly pure and free from other substances. See **Silver Nitrate.**

ARGENTOTYPE.—Dr. Mallman devised a process to which has been given this name. The following is a description of it† :

The following solutions are first of all prepared :

A.

Distilled water	100 c.c.
Ferric oxalate	20 grammes.

B.

Distilled water	100 c.c.
Silver nitrate	16 grammes.

* Mary S. Turner, in "American Annual of Photography."

† From *Die Photographische Rundschau.*

For use, the proportions are:

Solution A	8 c.c.
Solution B	2 c.c.

Suitable paper is coated with this mixture by artificial light, and the paper is rapidly dried by heat, in order that the solution may not sink too deeply into the surface. Either starch or dextrine may be added to the mixture. Exposed under a negative in the usual way, a reddish image on a yellow ground is obtained. Here is the developer recommended:

A.

Distilled water	1,000 c.c.
Potassic oxalate	160 grammes.

The oxalate should be feebly acidified with oxalic acid solution.

B.

Distilled water	100 c.c.
Potassium bichromate	4 grammes.

C.—Concentrated nitric acid.

For use take:

A	100 c.c.
B	12 drops.
C	4 "

The bichromate keeps the whites clear; for weak negatives, it is desirable to increase the quantity of it; for strong negatives, to decrease it. Development takes place in the cold. The tones vary a great deal; usually subsequent gold toning is necessary. After development the prints are passed through two or three changes of water acidified with nitric acid. A combined toning and fixing bath is recommended. Under-exposed prints may be intensified by means of a mixture of acetic acid, pyro and nitrate of silver; over-exposure is remedied by prolonged immersion in the wash water acidified with nitric acid.

The name has also been given to an English bromide paper sold ready prepared for enlarging or contact printing. See **Bromide Paper**.

ARISTOGEN.—A trade term for a concentrated solution of hydroquinone and for developing printing-out paper when the same has been but faintly printed and treated with potassium bromide.

ARISTOTYPE.—This name was first given by Dr. Liesegang to his gelatino-chloride printing-out paper process. The name in this country is used for paper prints made upon paper on which the silver salts are spread either with collodion or gelatine. See **Gelatino-Chloride Process** and **Collodio-Chloride Process**.

ARROWROOT.—The common name of the plant, *Maranta Arundinacea*, grown in the West Indies and exported to this country. Potato starch is called farina, or English Arrowroot.

ARROWROOT PAPER.—A paper sized with arrowroot, and used for heliotype and photo-lithography. It is also a good paper for the collodio-chloride process, platinotype, and for matt surface silver printing. It is used for sizing paper.

ARROWROOT PASTE.—See **Mountant**.

ARSENIC BROMIDE. (Formula, $AsBr_3$; molecular weight, 314.25).—Colorless deliquescent prisms with strong arsenical odor melting to a pale yellow liquid, which fumes but slightly in the air. Volatilizes unchanged, and yields a crystalline sublimate. It mixes with alcohol, ether and liquid oils, and is decomposed by water. It is added to collodion as a preserver, and to increase the intensity of the developed image. A solution for this purpose is prepared by reducing metallic arsenic to a fine powder, and placing it in a dry bottle with alcohol sp. gr. .805. Bromine is then added, a combination will ensue, and arsenic must be in excess. As before stated, it is decomposed by water, therefore strong alcohol must be used.

ARTIFICIAL LIGHT.—Artificial light, such as that produced by paraffin, gas, flash powder, magnesium, limelight or electricity, is largely used in photography for printing, and for lighting in portraiture. For particulars of each see under the different headings. The method of using artificial lights for portrait-taking is given under **Portraiture**, *q. v.*

ARTIQUE'S PROCESS.—A process for reproducing plans, drawings, etc. It is practically a modification of the carbon process, and is thus described: *

"The paper can be prepared with any one of the following solutions:

1st. Dissolve 2½ parts of ammonium bichromatic and 5 parts of best gum arabic in 15 parts of water and neutralize with a few drops of concentrated aqueous ammonia; then add 100 parts in volume of whites of eggs and a certain quantity of thick India ink, and this done, beat the whole to a thick froth. In ten or twelve hours the albumen will be deposited and ready for use.

* From "Photographic Reproduction Processes," by P. C. Duchochois.

The quantity of India ink added to the albumen should be such that the paper be black when coated, but sufficiently transparent, however, to enable one to see the shadow of objects placed at the back. The coating should not be thick. This is important, in order to allow the light to act through the whole thickness of the preparation when the paper is exposed under the cliché, for, if the film be too opaque or too thick (by addition of too much gum arabic), it would only be impressed on its surface, and the image dissolved during the development. The cause of this failure must be explained. Under the action of light the bichromate employed to sensitize the albumen is reduced into chromic oxide, which renders insoluble this organic substance—or any other, such as caseine, gelatine, gum arabic, etc, therefore, whenever the film is not acted on right through the film, the subjacent part, being still soluble, is necessarily washed off and with it the superficially impressed part, that is, the image.

2d. Take 10 parts of lampblack and work it up in a mortar to the consistency of a thin paste by gradually pouring a little of a solution of from 6 to 8 parts of gum arabic and 1 part of liquid glucose in 100 parts of water, adding afterward the remainder, into which 2½ parts of ammonium bichromate have been dissolved, and filter through flannel. With this, coat the paper by brushing so as to form a thin and uniform film, and pin it up to dry in the dark.

These solutions keep well for a certain period. We have kept the albumen, which we prefer to use, for two months in good condition; but the sensitive paper does not keep for more than three or four days, taking the usual care. It is more practical—and this is recommended—to leave out the bichromate from the preparations, and to coat the paper, in quantity beforehand, and for use to sensitize it with a 3½ per cent. solution of potassium bichromate and water applied to the back with a Buckle brush.* The bichromate solution should be allowed to soak through the paper for about one minute, and having brushed it once more, the paper is pinned up to dry in the dark-room. It can also be sensitized from the back by floating, if this method is found more convenient.

When dry, the paper is impressed under a negative cliché of good intensity until the design. well defined in all its details, is visible on the back of the paper, which requires an exposure of about two minutes in clear sunshine, and from eight to ten times longer in the shade. In cloudy weather, the exposure to light is necessarily very long.

As explained before, the luminous action, by reducing the chromic salt in presence of certain organic substances, causes the latter to become insoluble; consequently if, on its removal from the printing frame, the proof be soaked in cold water for, say, ten minutes, and, placing it on a glass plate or a smooth board, gently rubbed with a brush or a soft rag, the parts of the albumen or gum arabic preparation not acted on will dissolve, leaving behind the black image standing out on the white ground of the paper. This done, and when the unreduced bichromate is washed out in two changes of water, the operation is at an end.

As to the theory of this and similar processes, the insolubility of the bichromate organic substance acted on by light was formerly attributed to the oxidation of the substance by the oxygen evolved during the reduction of the chromic salt into chromic oxide; but from the fact that oxidation generally tends to destroy organic matters, or to increase their solubility, it is more probable that it results from the formation of a peculiar compound of the substance with chromic oxide (J. W. Swan); moreover, gelatine imbued with an alkaline bichromate, then immersed first in a solution of ferrous-sulphate and afterward in hot water, is insolubilized with formation of chromium trioxide, $Cr_2O_7K_2 + SO_4Fe = SO_4K_2 + C_2O_4Fe + C_2O_3$ (Monckhoven). A similar but inverse action occurs, as shown by Poitevin, when gelatine rendered insoluble by ferric chloride becomes soluble by the transformation, under the influence of light, of the ferric salt into one at the minimum.

The writer† has improved the above process by simplifying the *modus operandi* as follows:

Instead of compounding the preparation with gum arabic and the coloring matter, the albumen is simply clarified by beating the whites of eggs to a froth, etc., and the paper is coated by floating for one minute, then hung up to dry in a place free from dust.

If the reader has any objection to albumenizing his own paper, he can use the albumen paper found in the market for the printing-out silver process generally employed by photographers.

The paper is sensitized from the back with the potassium bichromate bath by floating or by brushing. When dry, it is exposed as usual, but for a shorter period than when the preparation contains the India-ink or other coloring matters which impede the action of light.

The progress of the impression is followed by viewing, from time to time, the albumenized side of the paper. When the design is visible, well defined and brownish, the proof, being removed from the printing-frame, is rubbed with very finely powdered, or, better, levigated graphite, and, this done, immersed in cold water for from fifteen to twenty minutes, when, by

* The Buckle brush is made by drawing half through into a glass tube a tuft of cottonwood by means of a string.
A piece of canton flannel folded in two and held between two large strips of glass plate tied together is also a convenient brushing apparatus.
In handling the alkaline bichromates, one should bear in mind that these salts are very toxic and act by absorption, producing dangerous skin diseases which become chronic, and are, consequently, very long to cure.—P. C. D.

† P. C. Duchochois.

gently rubbing it under a jet of water with a soft rag, or with a sponge imbued with water, the albumen is washed off from the parts not acted on, leaving the design on a perfectly white ground.

If, instead of graphite, or any dry color insoluble in water, lithographic inks, much thinned with turpentine oil, be applied on the print in a light coating which permits one to see the design under it, and if, then, the print be soaked in water and afterward developed as just directed, an image in greasy ink is obtained. And, furthermore, by replacing the printing by transfer ink, one readily obtains a transfer ready for the stone or a zinc plate to be etched in the ordinary manner.

As usual, there are two causes of failures in these processes, viz., under and over exposures. In the former case, the image is partly washed off; in the latter, the ground cannot be cleared. The reasons are obvious."

ARTOTYPE.—See **Collotype.**

ASBESTOS or **ASBESTUS**—A variety of the amphibole or hornblende family of minerals. Asbestos consists of fine crystalline elastic fibres possessing a silky lustre. It varies in color from white to gray or green. It derives its name from its property of being almost indestructible by fire. The finest quality is amianthus, the fibres of which are beautifully white and long. It is found in the Pyrenees and Alps. The best, however, comes from Tarantaise, in Savoy, and from Corsica.

Common asbestos is darker in color, and of lighter weight than amianthus. There are many varieties.

ASPHALTUM (Synonyms, *asphalt, bitumen, bitumen of Judea, mineral pitch, and Jew's pitch*).—A natural product of the decomposition of vegetable substances. It is found on the shores of the Dead Sea, also in a molten state in Trinidad, and as a mineral deposit at Seyssel. Small quantities have been found in Derbyshire, Cornwall and Shropshire.

Commercial asphalt is generally in brownish-black or black lumps, very brittle and nearly odorless. It varies in quality, but it can be purified by boiling in water, when the pure asphalt melts and floats upon the surface, while the impurities subside.

Asphalt melts at between 90 degs. and 100 degs., and burns with a bright flame. It may be dissolved in oil of turpentine, oil of lavender, benzine, and in solutions of alkalies and alkaline carbonates.

Alcohol, ether and chloroform will also dissolve asphalt. By dissolving successively, three different kinds, possessing different properties, can be extracted. The alcohol extract is an oily, odorous substance, yellowish in color, and slightly sensitive to light. The ether extract is a brittle substance, of a brownish-black color, and nearly odorless. It is a little more sensitive to light. The chloroform extract is a black, brittle, odorless residue, containing more sulphur, and much more sensitive to light, than the other extracts.

A method of preparing it for photographic purposes is given by Leaper as follows: The commercial product is finely powdered and digested with alcohol for a couple of hours in a closed vessel at a temperature of 40 degs. C., after which the residue is collected on a filter, washed with alcohol and left for several days in contact with an excess of ether. The *residue* is finally air dried and preserved in the dark. Sometimes adulterated with coal tar pitch. This can be detected by breaking a sample, when it will be seen to have a dull instead of a shining fracture.

This property of being sensitive to light makes asphalt exceedingly useful for photographic purposes, especially in photo-zincography and photo-lithography. The action of the light upon a coating of asphalt laid upon a zinc plate is to render it insoluble. Those parts not acted upon may be removed by a subsequent operation of washing with a solvent. This action of light is no doubt physical and not chemical, as the solubility can be restored by melting it. It withstands the action of acids, which are then employed to eat away into the uncovered portions of the zinc (see **Photo-zincography**). In photo-lithography another property of asphalt is made use of, *i.e.*, its attraction for the greasy ink (see **Photo-lithography**).

Mixed with oil, gutta-percha, or india-rubber, it makes a capital black varnish (see **Varnish**).

ASPHALTO-PHOTO-LITHOGRAPHIC PROCESS.—A process originally employed by Niepce in the production of heliographic engravings. It was based upon the light-sensitive properties of asphalt.

ASTIGMATION, or **ASTIGMATISM,**—A defect in a lens or combination of lenses, the result of which is a difficulty to obtain the same degree of sharpness round the margin as in the centre of the image. To test a lens for astigmation cut out a circular disc of white paper, or take a white wafer and attach it to a black ground. Focus on the centre of the screen. Now turn the camera until the image of the disc is seen at the margin, but indistinctly, and upon endeavoring to focus it it spreads out vertically or horizontally, and takes the form of an oval.

The reason of this is that for rays falling parallel to each other, but oblique to the axis of the lens, there are two focal lengths. One in the plane passing through the radiating point and the optical centre, and the other passing through the principal axis of the lens and the radiating point, but perpendicular to the first. This difference between the primary and the secondary focus is termed astigmatism or astigmation, and is usually found in lenses corrected for great flatness of field. The defect is also found in the eyes of a great number of persons. It may be reduced to a minimum by the use of a diaphragm. It will be seen that the diaphragm plays several important parts, which are more clearly explained under that heading.

ASTIGMATISM.—See **Astigmation.**

ASTRONOMICAL PHOTOGRAPHY, or **ASTRO-PHOTOGRAPHY.**—In the very earliest days of photography attempts were made to photograph celestial bodies. In 1838 Daguerre attempted to photograph the moon, but was unsuccessful. In 1840 some experiments by Dr. Draper, of New York, resulted in the production of lunar photographs 1 inch in diameter. In 1850 Professor Bond, of Cambridge, Mass., secured with the Harvard 15 inch refractor a daguerreotype of the moon, which was exhibited at the great London Exhibition in 1851, and caused no little sensation, as it was the first time that a distinct image of the moon's surface had been obtained. With the same instrument he secured a series of photographs of the double star Mizar. In 1853 Mr. Warren de la Rue obtained very successful results in lunar pictures, and in 1857 he constructed an observatory at Cranford, expressly for celestial photographic purposes.

With regard to the telescope used for photographic purposes, Prof. Barnard says:* "It is perhaps not generally known that a visual and a photographic telescope are quite distinctly different in the manner in which they deal with the light of an object. To be brief, it is only necessary to say that the visual telescope is corrected for that kind of light which gives the brightest image, but this comes from a portion of the spectrum that has no effect on the ordinary sensitive plate. Hence a visual telescope cannot be used successfully for photographing since the image, so distinct to the eye, cannot be photographed. In the photographic telescope, however, the image cannot be seen because it is formed from that portion of light which, though it has the strongest action on the photographic plate, does not have any effect on the eye. Or, more briefly still, the visual telescope is useless for photography, and the photographic telescope cannot be used for visual work. Hence, also, the reason that for photography two telescopes are used—one to photograph with and the other to see to guide by. But the Lick telescope really consists of the two kinds of telescope in one. That is, by the addition of a photographic correcting lens placed over the visual objective it can at once be converted into a photographic telescope. It is then only 33 inches in diameter—the correcting lens being smaller than the visual. The "guiding" for this instrument consists not in delicate adjustments to move the entire telescope accurately with the stars, but in moving the plate itself to correct irregularities of refraction, etc., during the exposure—the clock, in the meantime, carrying the telescope as best it can."

Although astronomical photography was at first regarded more in the light of curiosity than of utility, the advent of the collodion process, and afterward dry plates, changed all this, and there is no science that has benefited by the aid of photography to a greater extent than astronomy.

With regard to solar photography, the first attempt was made at Paris in 1845, by MM. Foucault and Fizeau, acting on the suggestion of M. Arago. Later, in 1851, attempts were made to photograph the total eclipse. In 1857 Warren de la Rue was commissioned by the Royal Society to construct an instrument specially adapted for photographing the sun at Kew Observatory. The resulting photo-heliograph may be described as a small telescope of 3½ inches aperture and 50 inches focus, with a plate-holder attached to thee ye-end, and guarded in front by a spring slide, the rapid movement of which across the field secured for the sensitive plate the virtually instantaneous exposure necessary, owing to the enormous light power of the sun. By means of this instrument the first solar pictures of value were taken, and a photographic record of the solar condition, recommended by Sir John Herschel, was begun, and continued to be carried on at Kew for fourteen years, 1858-72.

FIG. 37—PHOTOGRAPH OF SUN SPOTS.

The first really good photograph of the camera, however, was made in 1869, at the total eclipse of that year, by Prof. Stephen Alexander.†

The work of photographing the sun is now carried on in every part of the world, and there are few days on which the self-betrayal of the camera can be evaded by our luminary.

* The PHOTOGRAPHIC TIMES, August, 1895.

† Prof. E. E. Barnard, in the PHOTOGRAPHIC TIMES, August, 1895.

At the Lick Observatory photographs are made whenever the weather permits. A reflecting heliostat is used. This consists of a plain glass mirror mounted at the lowest extremity of an axis, which is parallel to the earth's. The mirror is so pivoted as to revolve about a second axis, perpendicular to the polar axis, which permits of its adjustment to the sun's declination, and when so adjusted is made to follow the diurnal motion of the sun by clock-work which revolves around the polar axis. In this way the earth's motion is neutralized and the reflected rays kept in a horizontal direction.

FIG. 38.—THE REFLECTING HELIOSTAT FOR SOLAR PHOTOGRAPHY.

The reflecting mirror consists of a circular glass plate $7\frac{1}{8}$ inches in diameter, slightly wedge-shaped, one surface of which is ground accurately flat This surface is figured with as much care as an objective, for upon its ability to reflect properly the rays which fall upon it, depends the perfection of the resulting image. This reflector is used plain, without any silver film to increase its reflective power, so that only a small proportion of the incident light (from 6 to 10 per cent), passes to the object glass to form the image.

The heliostat, objective and plate-holder are mounted on separate brick piers.

The focus of the instrument is inside the photographic dark-room at the other end of the telescope. At this focus is arranged a metal frame on a brick pier for holding the sensitive plate. On the wall, between the sensitive plate and the objective, is a vertical shutter working in guides, with a horizontal slit. The exposure is given by dropping this shutter so that it falls several feet before the exposing slit comes to the sun's image. The width of the slit is adjustable, and thus the exposure can be varied through the necessary range, the exposure varying with the attitude of the sun. The exposure of winter time is about 0".004, and this is decreased with the northward motion of the sun to about 0"002 in summer. The sun's disc is brightest at the centre, and toward the edge grows rapidly darker owing to the absorption of his atmosphere. The correct exposure for the central portions is too short for the edge *vice versa;* hence, an exposure is adopted which gives the best general result and is one which slightly over-exposes the central portions and under-exposes the parts near the edge or limb.*

FIG. 39.—PHOTOGRAPH OF SOLAR ECLIPSE.

Every eclipse expedition is fitted with complete apparatus for taking many views. In December, 1889, two expeditions were sent out, the one to Barbados, and the other to Loanda in West Africa, to watch and photograph the total solar eclipse of December 22d, to detect any possible change in the corona during the two hours and a half that elapse between totality at Loanda and at Barbados, and to determine the photometric intensity of the corona. Each observer took with him a reflecting telescope of 20 inches diameter fully equipped with arrangements for photographing. The focal length was only 45 inches, and the diaphragm diameter 15 inches; the focal aperture was therefore $f/3$.

* The foregoing description is by Prof. Perrine, in THE PHOTOGRAPHIC TIMES, December, 1895.

Probably the most photographed of celestial bodies is the moon, although little has been revealed that the eye cannot see. The largest number of portraits of this body has been made at the Lick Observatory. The great Lick telescope with its object glass of 36 inches diameter and 57 feet $\frac{4}{10}$-inch focus is a remarkable instrument, and when in front of this is attached a supplementary meniscus lens of 33 inches in diameter, the combination forms the largest photographic camera in the world, having a focal length of 47 feet $6\frac{2}{10}$ inches, and one especially suitable for photographing the moon.

FIG. 40.—PART OF A PHOTOGRAPH OF THE MOON.

The sensitive plate is held at the principal focus in a compound slide-rest, shown in the accompanying sketch (Fig. 41).* The frame AA is fixed in the tube at right angle to the optical axis. The frame D and everything above is movable in declination by the handle Decl.; the frame BC and the eye-piece G are movable in right ascension by the handle RA. The guiding eye-piece G receives a beam from the object-glass, and the image of a star can be kept on its curvatures by suitably moving the handles. The wires are lighted by a small incandescent lamp. The plate-holder FF, shown in the cut, is 8 x 10, the image of the moon is about 5 inches in diameter. I. and II. are curtains on spring rollers for quick exposures. The two handles and the end of G project several inches outside of the telescope tube. The whole apparatus can be rotated in position angle through 25 degrees on the ring BB.

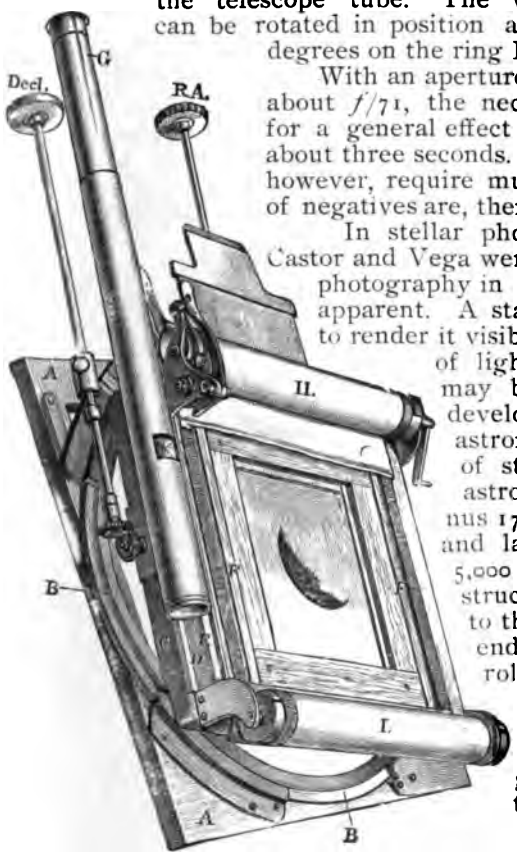


FIG. 41.—COMPOUND SLIDE REST FOR CARRYING THE NEGATIVE PLATE OF THE 36-INCH EQUATORIAL.

With an aperture of 8 inches, or about $f/71$, the necessary exposure for a general effect was found to be about three seconds. Bright regions, however, require much less, and the darker parts four or five seconds. A series of negatives are, therefore, made with different exposures.

In stellar photography we must go back to about 1850, when pictures of Castor and Vega were obtained by Bond and Whipple. Since this time the uses of photography in celestial investigations becomes every year more manifold and apparent. A star may be so weak that the beam of light it emits is too feeble to render it visible even with the most powerful telescope. But this faint beam of light, acting upon the more sensitive dry plate, will in time (it may be hours) succeed in making an impression made visible by development. So it will at once be seen how useful it must be to astronomers to have the means of recording faithfully the position of stars which he will never see. Some idea of the increase of astronomical knowledge may be gained from the fact that in Cygnus 170 stars had been carefully mapped out by hand by a lengthy and laborious process. An exposed dry plate, however, revealed 5,000 on a single plate taken in a few hours, and if we were to construct a telescope that would make these 5,000 stars directly visible to the eye there is no doubt that another dry plate exposed at the end of this telescope would reveal many thousands more worlds, rolling and shining beyond, veiled in the obscurity of immeasurable distance.

Not only have many thousands of invisible stars been revealed by photography, but many strange novelties. The great nebula in Andromeda, for instance, was for ages a mystery to astronomers until the photographs obtained by Mr. Isaac Roberts revealed the fact that it was composed of a number of rings of gaseous material apparently in a highly heated state, and undergoing some process of transformation Photography has, too, been the means of informing astronomers of the existence of a mighty nebula, hitherto unknown, surrounding the well-known group of stars, the Pleiades.

Not only in recording the position and appearances of heavenly bodies has photography been useful, but also as a co-worker with the spectrum in ascertaining the physical condition of

* From "Proceedings of the Lick Observatory."

these bodies. A photographic investigation on a novel system of the spectra of all the higher northern stars is now being prosecuted at Harvard College Observatory. The spectra are taken, as it were, wholesale; a large prism placed in front of the object glass analyses at once the rays of all the stars in the field. Captain Abney's remarkable extension of the powers of the camera in photographing the red and intra-fed rays has made it possible to explore a vast unknown and forever invisible region of the solar spectrum. And it will soon be possible to ascertain correctly the condition of the various kinds of matter ignited in the solar atmosphere.

The value of photography to astronomy is admirably described in the following words :*

"The observer must stand aside while photography takes his place, and works with a power of which he is not capable, and I feel sure that in a very few years the observer will be displaced altogether, while his duty will be done by a new sensitive being—a being not subject to east winds, to temper, and to bias, but one above all these weaknesses, calm and unruffled, with all the world shut out, and living only to catch the fleeting rays of light and tell their story."

Among the most recent astronomical discoveries by photography may be mentioned those of Dr. Max Wolf, who, with an ordinary photographic objective, discovered five new planetoids in a few months, besides a great many nebulæ. The planetoids appear as streaks on the photographic plate, and the length of the streak determines the course during the exposure. By this means photography has been instrumental in discovering and proving the motion of heavenly bodies.

The largest telescope now in existence (1896) is the Yerkes, with a diameter of 40 inches, thus eclipsing the great Lick telescope by 4 inches.

ASTRO-PHOTOMETRICAL.—Pertaining to the measurement of the light from the stars. See **Photometric.**

ATMOMETER.—An instrument to measure the quantity of water evaporated in a certain time under ordinary atmospheric condition.

ATMOSPHERE.—The gaseous vapor that surrounds the globe. See **Air.**

ATOM.—An atom is the smallest particle into which an element can be divided. Theoretically an atom cannot exist in a separate state, but unites with one or more atoms to form a molecule. The atoms of different elements have definite relative weights, fixed and invariable for each. The weight of an atom of hydrogen is regarded as unity. See **Chemistry.**

ATOMIC THEORY.—A theory promulgated by Dr. Dalton, and with a few exceptions received by chemists to this day. The theory is that all elementary bodies are formed of individual particles or atoms. That in the same element these atoms are exactly the same in size, weight, and every other respect, and that they differ from those of any other element in mass and in chemical properties.

In the outlines of chemistry, this theory is more clearly explained. See **Chemistry.**

ATOMIC WEIGHT.—The term atomic weight is often employed as synonymous with the term chemical equivalent. But the ideas of the two are distinct; for whereas there can only be one atomic weight of a simple substance, yet there may be two or three chemical equivalents for the same elements. The atomic weights of the different elements are given under **Elements,** See also **Chemistry.**

ATTRACTION, CHEMICAL.—See **Affinity.**

AURANTIA (Formula, $C_1H_4(NO_2)N,NH_4$; molecular weight, 456). Synonym, *hexanitro diphenylamin ammonia.*—A beautiful orange dye, the ammonia salt of an acid. Mixed with collodion and formed into pellicles it is used in the orthochromatic process as a color screen. It is also employed as a color sensitizer for plates. See **Orthochromatic Photography.**

AURANTIA SCREEN.—To make an aurantia screen for orthochromatic photographic purposes, dissolve a small quantity of the dye in alcohol, and add this to a plain collodion. Talced glass is then coated, and, when dry, the film stripped from it.

AURIC.—A derivation from the Latin term *aurum*—gold, and is used to indicate certain substances having gold as one of its constituent elements as auric chloride—gold tri-chloride.

AURIC CHLORIDE.—See **Gold Chloride.**

AURIN (Formula, $C_{19}H_{14}O_3$; molecular weight, 290). Synonym, *trioxytriphenyl-carbinol, Rosalic acid* and *yellow coralline.*—A red coloring matter, obtained from phenol or carbolic acid. It is soluble in alcohol and ether but insoluble in water. It is used for dyeing fabrics suitable for lighting dark-rooms Collodion stained with aurine and coated on the back of plates will prevent halation.

AURUS CHLORIDE.—See **Gold Chloride.**

AURUM.—A Latin name for gold, sometimes used to denote that metal. See **Gold.**

*H. C. Russell, in an address to the Australasian Association.

AUTOCOPYIST.—A name given to a simplified method of albertype or collotype printing. The image is made on bichromated sheets of gelatine, and these are printed from by means of an ordinary letter-copying press. See **Prototype**.

AUTOGRAVURE.—A photo-mechanical process worked in England. It is a modification of the well-known etching process, by means, first, of a bituminous ground on the copper, and, secondly, by the transfer of the photographic image from a reversed transparency on to the copper. Etching is then done with solutions of iron perchloride.

AUTOMATIC PHOTOGRAPHY.—The invention of Monsieur Enjalbert, exhibited at the Paris Exposition of 1889. It consists of an automatic machine designed to perform all the photographic operations necessary to obtain by the ferrotype process the portrait of an individual who sits in front of it, and who has previously dropped a sufficient number of coins into the cash box. When the money is dropped into the slot, the electric machinery is at once set into motion. On the left of the machine directions are given as to the point upon which the eyes must be fixed during the exposure. Above there is a series of dials, divided into sections, and a revolving hand indicates at every instant the operation that is taking place inside of the apparatus. A few instants before the exposure the hand of the second dial pass over the words "Prepare yourself," and then "Attention," and as soon as it reaches the black section marked "Posé," the exposure begins, and a bell above rings as long as the exposure lasts—usually from three to six seconds. In a few minutes—the total operation lasting but five minutes—the finished ferrotype portrait makes its exit from the side to the astonished if not delighted sitter. Similar machines have been introduced in America. The majority of them, however, have proved failures owing to their complicated nature and to the uncertainties of photo-chemical operations.

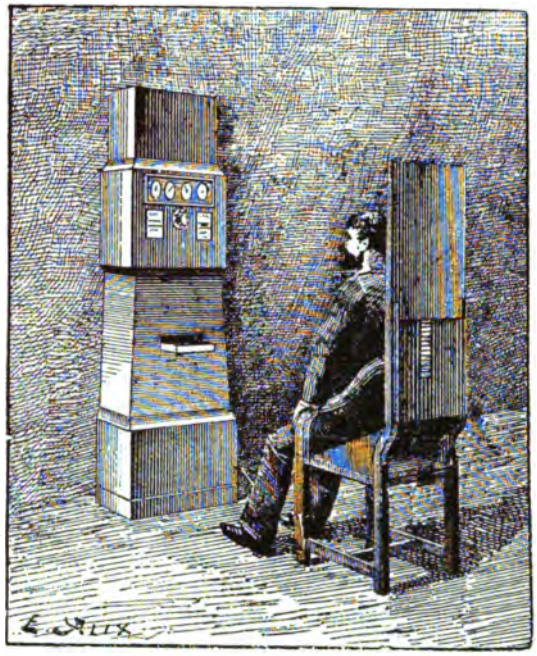


FIG. 42.—ENJALBERT'S AUTOMATIC MACHINE FOR PHOTOGRAPHING.

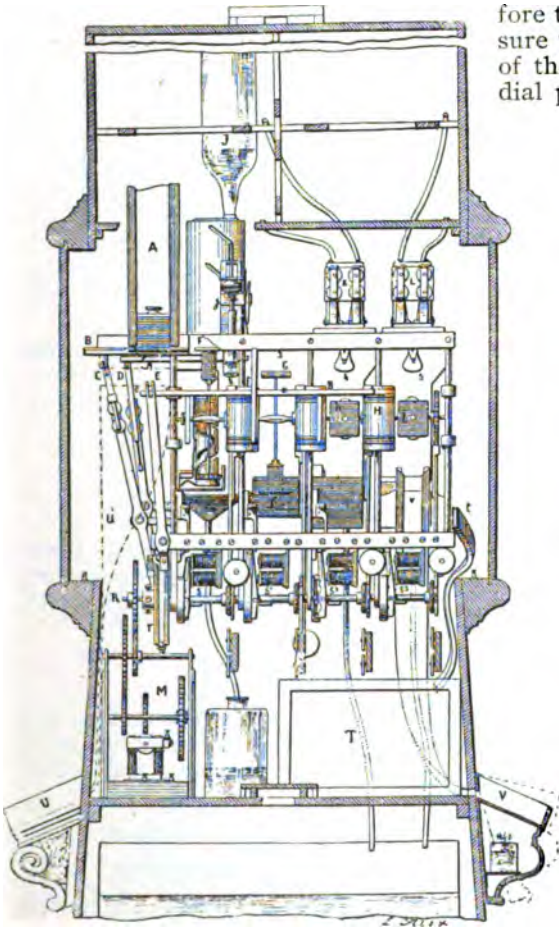


FIG. 43.—ENJALBERT'S AUTOMATIC MACHINE FOR PHOTOGRAPHING (INTERIOR).

AUTOMATIC PRINTER.—A machine devised by Urie, of Glasgow, for automatically printing upon strips of sensitive bromide or chloride paper. A band of the paper passes under the negative, over which is placed a gas burner. Between the burner and the negative is a dish containing cold water. This diffuses the light and prevents the heat from the burner attacking the negative. The whole machine is worked by clockwork, set in motion by weights. The automatic movements of the machine are these. A portion of the band of sensitized bromide paper comes into position under the negative, and is pressed against it with a pad; the gas light is switched on, and remains burning for a number of seconds previously regulated. The light is turned down, the band makes another revolution, and the same action takes place. The machine requires no attendance after once being set in motion until the band of paper is exhausted. Several thousands of prints per day may be made in this manner. They are developed in strips, as the exposure has been exactly the same in every case.

A very complete arrangement is now in use in America. Fig. 44 shows the mechanism employed for exposing. Prior to the moment of exposure, the cam, as it rotates, permits the pivoted weight to draw the bell crank lever supporting

the platen, and press the platen upward against the underside of the paper, placing the sensitive side of the latter in contact with the negative during the interval of exposure to the electric lights (usually two seconds); it is then drawn down until a fresh section of paper passes under the negative and the operation repeated. The movement is quite similar to the platen of a printing press.

Fig. 45 shows the arrangement employed for developing the exposed paper. The paper after passing over the submerged roll and down again, thence up out of the tank over the roll between the first and second tanks and down into the fresh ferrous oxalate developer in this tank, shows the images half developed out.

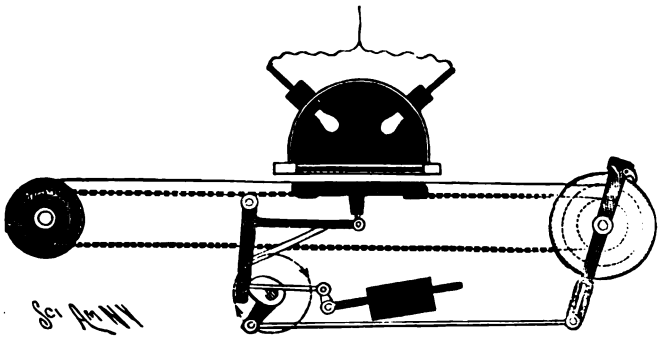


FIG. 44.—AUTOMATIC EXPOSING APPARATUS.

Coming out of the second tank, the images are fully developed, thence the paper passes on into the third vat, containing dilute acetic acid, which dissolves all of the iron left in the paper from the developer, and acts as a check to further development, thence in the next vat the paper is washed with water; next it passes into a fixing vat containing a solution of hyposulphite of soda, is again washed in the following tank then it passes into a vat of alum water, which hardens the film, and finally goes through two or three vats of water, receiving final spraying, as shown in Fig. 45.

From the last spraying it is led on to an endless canvas carrier into a long inclosed chamber filled with a current of warm air, heated by a gas furnace at the end. At the end of this heated chamber the paper comes out perfectly dry, and is rolled up with the pictures all on it. When the run is complete the roll of pictures is unwound, they are cut off to the respective sizes desired, and mounted in the usual way.

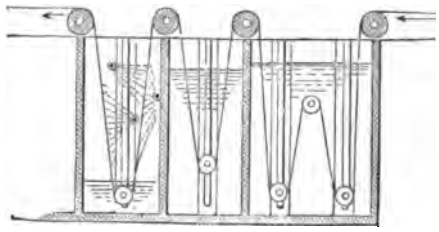


FIG. 45.—THE DEVELOPING TANK.

AUTOTYPE.—In England this term is applied to the carbon process of printing. In Germany and Austria it is used to denote photo-engraving or half-tone work. In this country it is also employed to designate a process by which photographs can be enlarged to the natural size by optical apparatus.

AUTOTYPOGRAPHY.—A process invented by Willis, by which drawings made upon gelatine may be transferred to metal plates, and afterward used for printing from like ordinary copper-plates.

AUX DEUX CRAYONS.—A peculiar printing process thus described:* Make two solutions, viz.:

No. 1.

Aloes, powdered	1 ounce
Alcohol	12 ounces

No. 2.

Water	12 ounces
Liq. ammonia	15 drops

Immerse the prints in solution No. 1 until they take a bright lemon color, then wash them well and put them in solution No. 2. Let them remain until they take a warm orange color, and again wash them. Mount and touch up the whites with Chinese white and the blacks with India ink. Afterwards coat with:

Plain collodion	6 ounces
Castor oil	12 drops

AUXILIARY EXPOSURE.—The sensitive dry-plate, either before or after exposure in the camera, is exposed for a fraction of a second to a weak, diffused light. This method has been several times recommended by competent authorities for under-exposed negatives, and softer effects are stated to be the result.

AUXOMETER.—An instrument to determine the magnifying power of an optical system.

AVOIRDUPOIS.—The name of a system of weights. See **Weights and Measures**.

AXIS.—The axis of a lens is an imaginary line passing through the centre of its curved and at right angles with its plane surface. A ray of light passing along it is the only one that is not refracted. See **Optics**.

* W. Bell, in "Wilson's Quarter Century."

AZALIN.—A trade term for a mixture of 10 parts of quinolin red and 1 part of cyanin blue, dissolved in 1,000 parts of water. It is used in orthochromatic work to sensitize plates for the red and yellow rays. The bath is prepared as follows*:

Azalin solution	1 part
Liquid ammonia	1 part
Alcohol	30 parts
Water	70 parts

AZOTE.—An almost obsolete term for Nitrogen, *q.v.*

AZOTIC ACID.—An almost obsolete name for Nitric Acid, *q.v.*

BABY HOLDER.—An adjustable seat for posing infants when photographing them (Fig. 46). This arrangement, often employed by professional photographers, has the appearance of an instrument of torture, and is hardly likely to assist the photographer in obtaining natural portraits of children.

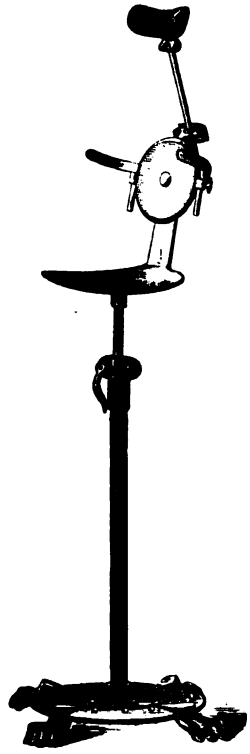


FIG. 46.—BABY HOLDER.

BACK COMBINATION.—That portion of a doublet lens situated nearest the focusing screen. In a portrait lens the back combination shortens the focus, giving greater illuminating power, and also serves to flatten the field of the image formed by the anterior combination. This it performs by virtue of its negative aberration. According to Traill Taylor, it is often possible to convert a bad lens into a good one by readjustment of the back combination, many portrait lenses having the back lenses placed loosely in their cell and kept apart with a brass ring. He mentions a case where by removing the separating ring of the back combination and bringing the front and back lenses close together a first-class lens was made from a bad one.

BACK FOCUS.—See **Focus.**

BACKGROUND.—The representation of the most remote portion of a landscape, or of the space and objects behind the principal figures. In studio portraiture artificial backgrounds are placed behind the figure; these may be plain, graduated, or ornamented, but should always be in unison with the subject.

Plain Backgrounds.—For a plain background painted canvas stretched on a suitable frame is usually employed, although almost any material can be used. If of an uneven texture it should be placed as far behind the sitter as possible. The color or tint should be in accordance with the object or person photographed, and so arranged as to show up the image by judicious contrast.

In painting backgrounds, distemper is superior to oil colors, which have a glaze. The color should be quite dead and opaque. A good distemper may be made as follows:

Water	1 gallon
Treacle	1 pint
Glue powder	½ lb.
Whiting	2 lbs.

Mix the above thoroughly and add—

Ivory black	2 ounces
Red ochre	¼ ounce
Ultramarine	½ ounce

A formula for a fireproof distemper for backgrounds is given as follows:†

Kaolin	8 parts
Whiting	4 parts
Ground flint or infusorial silica	8 parts
Finely-chopped asbestos	4 parts
Thick silicate of soda solution	12 parts

These being thoroughly incorporated, the required amount of water and color can be added. Obviously, colors affected by alkalies must be avoided; but for studio accessories lamp-black and the ochres meet all needs. Wood painted with the above is very difficult to kindle.

Graduated Grounds are now largely used. In these the tint is graduated so as to light up the figure on one side and darken it on the other.

The usual method of making a graduated ground is by stretching a piece of wet common sheeting on to a suitable frame. Dry powder color is then mixed with dextrine and dusted over

* Wall's "Dictionary of Photography." † "Photographic Work," 1884.

it. The pigment is next worked into the fabric, and the light and shade delicately blended by skillful application of the brush.

There are other methods for obtaining backgrounds of this description, the best results being obtainable by means of the air-brush. This gives very delicate and soft results. Those, however, who do not possess this instrument may construct a similar contrivance which will answer the purpose almost as well. Get a scent-spray and study the arrangement. It will then be easy to construct something similar on a larger scale. With such an arrangement the most perfect graduated grounds may be produced with a little practice. The color should be mixed with water and a little dextrine to fix it.

A still more simple method is to take a stiff brush lightly charged with color and tap it against a stick held firmly in the hand over the paper or canvas, or just moisten the tips of the bristles and draw some rigid substance along them, or rub over a comb or stout wire gauze. The color will be thrown upon the canvas or paper in little dots, and with care can easily be regulated as to density to obtain the right effect of gradation from light to dark.

A curved background, giving graduated effects at will of the operator, was devised by M. Salomon, and is described as follows*: At the back is a rod, *E* (Fig. 47), terminating in a series of loops and pulleys. Through these pass cords which are attached to the canopies *C* and *D*. The cords are all brought to a position behind or at the side of the background, where the operator can readily manipulate them, each cord having a counterpoise attached so as to maintain the canopy in any position into which it is pulled by the manipulator. The wings and canopy *B* and *C* are light frames covered with thin transparent white muslin, transmitting some light, but arresting or breaking up direct rays of sunlight. At each end of the canopy *C* is attached a piece of thin muslin, which we have not figured, as it would have somewhat confused the diagram. It is the same width as the wings, over the top of each of which a piece hangs to maintain the continuity between the wing screens and the projecting canopy. The canopies *D* are also light frames covered with thick white calico, transmitting very little light. The background rests on three feet, one at each side and one in the middle; these each project behind about eight inches to give firmness and steadiness. Each foot has a large castor to permit the whole to be wheeled round easily into any position. The wings are hinged so as to hang an inch or two from the ground, and are very easily moved backward and forward. The background is papered with salmon-colored printing paper. The sitter is placed within the curve, and the background, which is made to run easily, is moved round him until the right effect is produced, the curved screen being used to regulate the amount of light admitted on the lighted side, and to act as a reflector on the shadowed side, as well as to form a background, which, by its light and shade, gives space and relief to the figure.

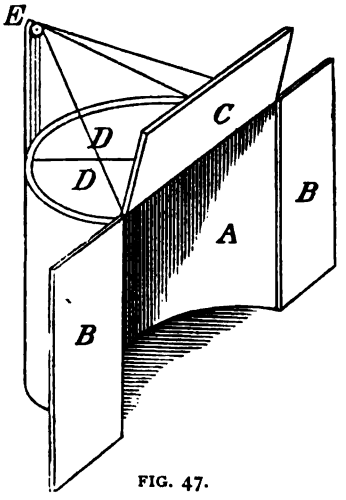


FIG. 47.

Other methods of producing graduated effects have been devised; one worth mention is the circular or revolving background. Over a large hoop about 4½ feet in diameter, having cross-pieces and an axis, canvas or muslin is stretched. This is then painted with a neutral tint and graduated. It is started on a revolution at the moment of exposure, or worked half-way round only with a pendulum.

Circular Backgrounds.—These are large round discs painted dark on one side and light on the other, the two tints blending together. The disc is made to revolve so that the graduated effect of light and shade can be arranged in any position behind the figure. Softer effects are obtained by moving the background during the exposure. They can only be employed for bust or half-length pictures.

A circular background was recently devised by the author, although the idea may not be new. A round disc, or a hoop stretched over with canvas and supported by bars across so that it could be revolved easily, was first constructed; this was painted over, half black and half white, as in Fig. 48. Another half circle (Fig. 49) of thick card or canvas stretched over a frame was arranged to fit in front of the circular disc. This semi-circle was painted one side white and the other black. It is not difficult to see that this could be screwed on to the circular disc so as to show a perfect white or a perfect black all over, or any quantity of white or of black, as in Figs. 50, 51. On whirling the disc round during the exposure, a

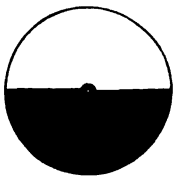


FIG. 48.

FIG. 49.

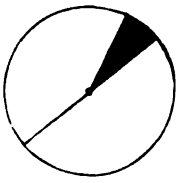


FIG. 50.

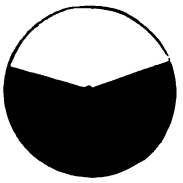


FIG. 51.

* Wilson's "Quarter Century."

soft tint of any shade can be obtained. An electric motor would be the best for the purpose, as the disc requires to be revolved with great rapidity, especially with short exposures.

Ornamented Backgrounds are those made to represent scenery or distant objects. Except they have been painted by a competent artist they are best avoided, as rarely are pleasing effects obtained by them—so atrociously untruthful, and so glaring the faults of the average scenic background, that the more out of focus they are placed the better they appear.

FIG. 52.—PORTRAIT WITH DARK BACKGROUND.

As a rule, the background should be a shade darker than the middle tints of the picture, and in vignette pictures a shade lighter, though to this rule there are many exceptions, and it is only the true artist who knows how to select his background to the best advantage with each subject.

Natural Backgrounds are undoubtedly the best when it is possible to include them in a picture.

Perhaps one of the best proofs of the gradual development of artistic feeling among photographers is the noticeable decay in the use of outrageously unsuitable backgrounds painted to represent all sorts of scenes.

FIG. 53.—PORTRAIT WITH LIGHT BACKGROUND.

At one time, it is true, the public were not satisfied to be photographed unless the picture represented them leaning on a marble pedestal in the midst of a marble palace, or seated on an impossible rock by the side of a still more impossible sea, dressed in a frock coat and chimney-pot hat, or, if a lady, in a low-necked ball dress standing out in a snow-covered landscape.

But we have changed all this, and now the majority among the educated classes prefer a picture made as simply and as plainly as possible.

In the selection of backgrounds for portrait work the two chief conditions to be observed are simplicity and harmony.

The advantage to be gained by simplicity is that the eye is not then attracted from the main object of the picture. It is for this reason that plain or graduated backgrounds are employed.

FIG. 54.—PORTRAIT WITH GRADUATED BACKGROUND.

If scenic backgrounds are used they should be by some good artist, and contain as few objects as possible, and invariably used with careful attention to harmony. One important rule to be observed is that there should be no line or object in the background immediately behind the head of the figure which should show out by itself, independent of everything else. Nothing is more ridiculous than the effect, so often seen in unskillfully made portraits, of a branch of a tree growing out of a man's ear or the top of his head.

With regard to the depth of shade of the background, the artist must exercise his own judgment with every class of picture. As a rule, the head should be surrounded by a tint a shade darker. If all the face is to be made to stand out in bold relief, then a very dark background can be used. If, on the other hand, the face is required to be in shadow, then a lighter background must be employed, care being taken that by so doing the appearance of a dusky complexion is not given to the sitter. Study the laws of contrast by examining a number of pictures and the effects that the backgrounds give to them.

In arranging a picture it is preferable to first pose the figure and then fit in the most suitable background. With graduated effects we can then adjust them so as to throw up the image as desired. With this class of ground where the shadows are deepest at the bottom the effect of solidity is given to the picture.

Never place the background too close to the sitter, or in using a natural background never focus any of the objects too sharply. If the picture is intended for a portrait, there should be nothing entering into competition with the head.

BACKING.—Dry plates possessing very translucent films are much affected by halation (see **Halation**). To remedy the defect the plate is treated with a "backing." This backing may be made as follows:—

Water	10 ounces
Gum	1 ounce
Powdered burnt sienna	1 ounce

This solution is brushed on the back of the plate with a stiff brush, or an india-rubber

roller charged with the color passed over the back. After exposure, and previous to development, it should be removed with a tuft of cotton-wool. Another formula:

Water	1 ounce
Glycerine	1 ounce
Gelatine	1 ounce

The gelatine is first soaked and then dissolved in the water, and the glycerine added. Sheets of black paper are then coated, and when set, cut into the sizes required. Before placing the plate in the camera a piece of the paper is pressed on to the back. After exposure it is easily removed and may be used again. A piece of black carbon tissue, black glazed paper, or American cloth, wetted and squeegeed into contact with the back of the plate, will answer the same purpose.

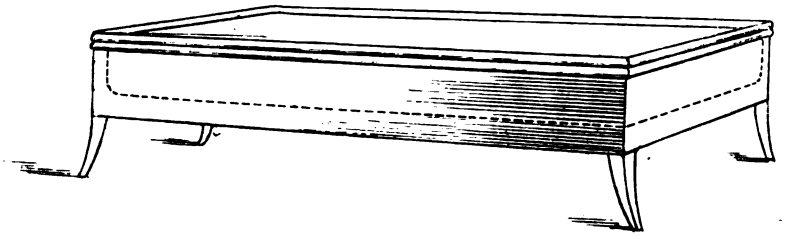


FIG. 55.—BAIN MARIE.

There are also other methods of backing plates equally effectual. Abney recommends ordinary printers' paper coated with gum arabic, stained with aurine or a blue absorbent dye, and fastened on to the plate. Cornu recommends a mixture of 6 parts of oil of cloves and 1 part of oil of turpentine made into a paste with lampblack.* Perhaps the best backing for a plate is a thin solution of asphaltum dissolved in benzole.

BACK SUPPORT.—An attachment to the ordinary head-rest to support the back of persons taken in a standing posture.

BAG.—See **Negative Bag** and **Changing Bag.**

BAIN MARIE or **BALNEUM MARIÆ.**—A waterbath. The substance to be heated being placed in a proper vessel, the latter is placed into another vessel containing water and capable of standing the application of fire by which heat is gradually communicated. An arrangement of this kind, as shown in Fig. 55, is used in developing carbon prints and for similar purposes. One of its advantages is that the water contained in the inner vessel can never reach boiling point, and a small amount of solution can be kept at an even temperature.

BALANCE.—An instrument for determining the relative weights or masses of bodies. The ordinary balance consists of a beam with its fulcrum in the centre and its arms precisely equal. From the extremities of these arms are suspended two scales, the one to receive the object or substance to be weighed, and the other the counterpoise.

FIG. 56.—ORDINARY BALANCE.

The possession of a good balance is of great importance to photographers and experimenters, as in many delicate processes a trifling error in the weighing of the necessary chemicals will make an important difference in the results.

A good balance should possess both stability and sensibility, or, in other words, it should not oscillate for any considerable time after being disturbed, and it should sensibly move upon the addition of the minutest particle of matter to one of the scales. For weights, see under **Weights and Measures.** For quantitative analysis, a very delicate balance, such as that shown in Fig. 59, will be requisite.

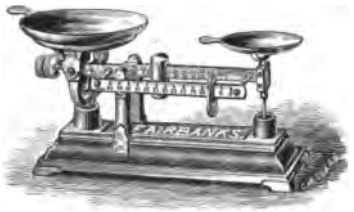


FIG. 57.—BALANCE FOR WEIGHING LARGE AND SMALL QUANTITIES.

Fig. 57 shows the construction of a handy form of balance. It combines two forms. The small pan and light beam are suitable for weighing small quantities up to 60 grains, and the large pan and beam weighing from one-quarter to 8 ounces. In Fig. 58, we have a balance specially designed for weighing liquids instead of measuring them. They are provided with a tare beam for balancing the bottle before commencing to weigh the solution.

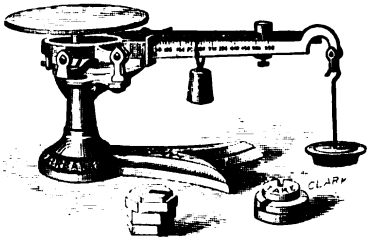


FIG. 58.—BALANCE FOR WEIGHING LIQUIDS.

The following contrivance for weighing very minute quantities can easily be constructed by those possessing skill and perseverance. It is called a torsion balance. Fig. 60 will serve to show its construction. A

* E. J. Wall.

thin platinum wire is stretched horizontally through the staples from the wooden supports A B, firmly fixed on a stout deal board. An upright piece of wood, G F, is also firmly attached to the board, strengthened, if necessary, by a side piece. A very thin delicate lever, D, cut in wood, is fixed to the centre of the platinum wire by means of a clip, H, securing it firmly in such a manner that it is raised perceptibly out of the horizontal line. If a centigramme be placed on the lever at D, it is lowered to a certain point, twisting the platinum wire, and its position marked on a piece of paper attached to the upright piece G F. The space between the two points marked by the lever with and without the weight is then divided and marked into ten equal divisions, which will represent the distance that will be traversed by the lever under the weight of a milligramme. If we wish to weigh, say, five milligrammes, a sufficient quantity of the substance is placed on the lever until it falls five divisions.

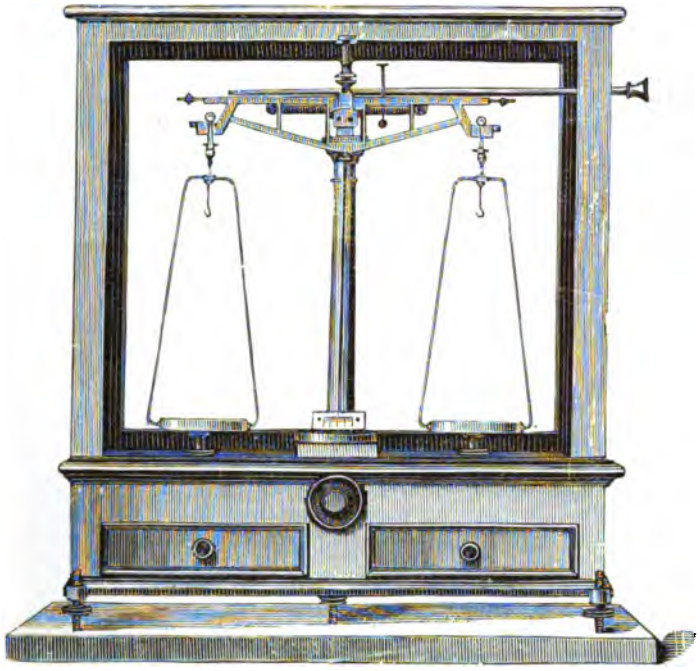


FIG. 59.—BALANCE FOR WEIGHING MINUTE QUANTITIES.

Another simple contrivance, which is within the power of anyone to construct, is a Nicholson aerometer, Fig. 63, which serves as an excellent balance. A glass balloon, B, filled with air and hermetically sealed with a cork, is made to receive a piece of wood surmounted by a wooden disc, D. At the lower end of the balloon is attached a small tray to hold pieces of lead. It is then placed in a glass filled with water, and the upper portion, and the wooden stem, held in position by means of a ring attached to four pieces of wire which firmly clip the sides of the vessel. Sufficient lead is then placed on the tray C until the stem rises almost entirely above the level of the water. This stem should be divided in such a manner that each division represents the volume of a cubic centimètre. We have now a perfect balance; the subject to be weighed is placed on the disc D, and the number of divisions the stem sinks corresponds to the number of cubic centimètres of water displaced, or the weight of the substance in grammes. Thus, if the stem sinks six divisions, this represents the displacement of six cubic centimètres of water, and the weight of the substance is therefore six grammes.

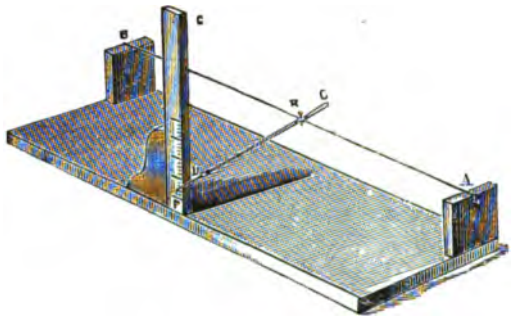


FIG. 60.—TORSION BALANCE.

The difficulty of weighing out liquids which readily volatilize, of fuming acids, etc., has been experienced by every chemist and photographic experimenter. To simplify the process, Messrs. H. Schweitzer and E. Lundwitz have devised a pipette, shown in the accompanying illustrations (Figs. 61, 62). The arrangement is thus described *: The exhaustion tube terminates in a capillary, which is bent within the bulb of the pipette toward the upper portions of its walls; the opposite side of the bulb is flattened in order that the pipette can be placed on the pan of the balance; the mouthpiece may be drawn out to a capillary, and the same applies to the discharge tube. A sufficient quantity of the liquid to be weighed is sucked up into the bulb so that the end of the capillary within the bulb projects beyond the surface of the liquid when the instrument is laid down on the flattened portion. After wiping the end of the tube, the pipette and its contents are weighed; the necessary quantity of liquid is then run out, and the weight redetermined. For weighing solid fats the instrument may be warmed; the error introduced by weighing a slightly warm liquid in a small pipette being for practical purposes quite negligible.

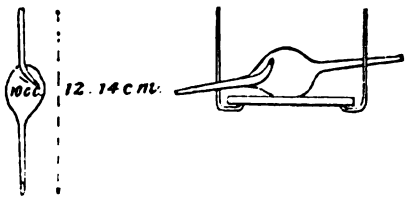


FIG. 61. FIG. 62.

* *The Pharmaceutical Era.*

BALANCE (IN ART).—A picture is said to balance when the relation of the lines, lights and shadows are such as to secure a harmonious whole.*

BALANCE OF COLOR.—Colors are said to balance when by opposition they are so neutralized that no one appears to predominate.

BALLOON PHOTOGRAPHY.—See **Aerial Photography.**

BALMAIN'S PAINT.—See **Luminous Paint.**

BALNEUM MARIÆ.—See **Bain Marie.**

BALSAMO'S PROCESS.—A printing process invented by Prof. J. G. Balsamo. Phosphorus is digested for a considerable length of time in hydrocyanic acid. The solution is better after having been kept some time. When the acid is saturated with phosphorus, it is diluted with acetate of copper until the liquid turns an olive green color. Paper is immersed in this for three or four minutes, dried and exposed under a negative until those parts acted upon by the light have assumed a grayish color. After removal from the printing-frame, the positive is exposed to the vapor of sulphuretted hydrogen, which attacks the exposed parts. The print is then washed for some time to remove the superfluous copper salts. It can be toned in nitrate of bismuth.

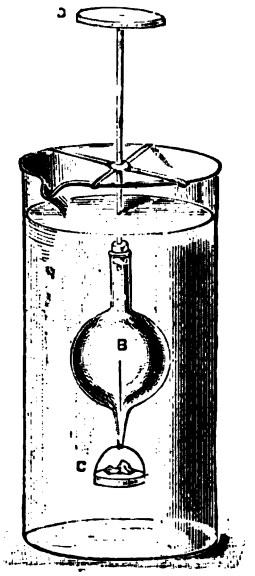


FIG. 63.—NICHOLSON'S AEROMETER.

BALSAMS.—Exudations from certain trees and plants, and consist of liquid or solid substances resembling a resin, combined with benzoic acid. Canada balsam (*q. v.*) is used for cementing lenses.

BARIUM (Symbol, Ba ; atomic weight, 137).—A metallic element prepared by the decomposition of barium chloride. Pure barium is never found native, but only in combination with other substances. Its chief sources are the native carbonate and sulphate, *q.v.* The great density of its compounds has given its name.

BARIUM BROMIDE (Formula, $BaBr_2 . 2H_2O$; molecular weight 333).—A salt prepared by saturating barium carbonate with hydrobromic acid. It occurs in white tabular crystals. It is very soluble in water, ether and alcohol, and is sometimes employed in collodion. It is poisonous.

BARIUM CHLORIDE (Formula, $BaCl_2 . 2H_2O$; molecular weight, 244).—Barium chloride is prepared from the native carbonate or sulphate. It is sold in the form of white crystals, soluble in about two parts of water. The crystals contain two molecules of water, which are expelled at 212 deg. Fahr., leaving the anhydrous chloride.

Commercial barium chloride often contains strontium and calcium chlorides. These impurities may be removed by dissolving the crystals in alcohol. It is soluble in water and very slightly so in alcohol.

Barium chloride is extensively used as a reagent for detecting and estimating sulphuric acid, by which it is precipitated as barium sulphate. It also forms a white precipitate with carbonate and sulphate of potassium. Mixed with chloride of gold, barium chloride gives a surface sensitive to light. It is sometimes employed as a substitute for sodium or ammonium chloride in salting albumenized paper. It is poisonous.

If an unexposed but fixed dry plate be immersed in dilute sulphuric acid and then, without washing, immersed in a solution of barium chloride, a fine deposit of barium sulphite is formed in the film, and the plate serves as an excellent focusing screen superior to ground glass.

BARIUM IODIDE (Formula, BaI_2 ; molecular weight, 391) occurs in deliquescent tabular crystals obtained by heating iron filings and iodine till colorless, and then adding barium hydroxide until the formation of a precipitate ceases, filtering and evaporating ; soluble in water ; nearly soluble in alcohol. Sometimes employed in collodion.

BARIUM NITRATE (Formula, $Ba(NO_3)_2$, molecular weight, 261 ; synonym, *nitrate of baryta*).—Prepared by dissolving barium carbonate in a weak aqueous solution of nitric acid, and crystallizing. It forms octohedral crystals, permanent in the air and moderately soluble in water, but insoluble in alcohol. It may be used instead of lead nitrate in the preparation of ferrous-nitrate, used as a wet plate developer. It is also added to the negative nitrate bath as a preventive against the formation of pinholes in the collodion film by decreasing the solvent action of silver nitrate upon silver iodide. It is soluble in water and insoluble in alcohol, and is poisonous.

BARIUM SULPHATE (Formula, $BaSO_4$; molecular weight, 233).—Found native as heavy spar, or produced as a white salt when sulphuric acid is added to a soluble salt of barium. It is used in the manufacture of transfer paper for the carbon process, and baryta paper.

* The subject is fully dealt with by H. P. Robinson, in his "Pictorial Effect in Photography."

BARIUM SACCHARATE (Formula, $BaOC_{12}H_{22}O_{11}$).—Barium saccharate is sold as a white crystalline powder, soluble in water, and poisonous. It is sometimes employed as an alkali in development.

BAROMETER.—An instrument for estimating the weight or pressure of the atmosphere, invented by Torricelli in 1643. Torricelli discovered that if a tube closed at one end and free from moisture be filled with mercury and turned over in a dish containing mercury, the mercury in the tube will sink to a certain height (30 in.), leaving a perfect vacuum at the top. When the pressure of the air is increased the mercury rises, and falls on its decrease. Upon this principle barometers are constructed. By means of a float on the mercury and a wheel, the movements of the mercury are communicated to the pointer, or hand, on the visible dial.

The aneroid barometer is now largely used. The term "aneroid" is given to it because it is "without moisture." In an instrument of this kind the atmospheric pressure is held in equilibrium by an elastic metal spring or tube. A metal box is freed from air and hermetically sealed. This box has a flexible side, the elasticity of which and the pressure of the air upon it keep each other in equilibrium. Upon this elastic side the short arm of a lever is pressed, while the longer arm works an index point, as in the circular barometer. When the pressure increases the elastic box gives, and when the pressure diminishes it returns to its former place, and the index moves in the opposite direction. A curved tube is sometimes used, which coils and uncoils like a spring according to the pressure on it.

The uses of the barometer are various. It is employed to calculate the height of mountains, for a barometer at sea level stands much higher than on a mountain top, because the amount of air is less, and consequently exercises less pressure upon the mercury.

In all barometric observations there are two essential corrections to be made, one for the capillarity or depression of the mercury in the tube, and the other for temperature. The following are the corrections for the capillarity or depression of the mercury in tubes of different diameters, as pure mercury always assumes a convex surface in a glass tube. These corrections are made according to the theory of Ivory.*

Diam. of Tube. Inches.	Depression. Inches.	Diam. of Tube. Inches.	Depression. Inches.
.10	.1403	.40	.0153
.15	.0863	.45	.0112
.20	.0581	.50	.0083
.25	.0407	.60	.0044
.30	.0292	.70	.0023
.35	.0211	.80	.0012

BARREL DISTORTION.—See Distortion.

BARYTA (Formula, BaO).—The monoxide of barium obtained by heating either the nitrate or the barium carbonate. Baryta is an alkaline earth, poisonous, and not readily fusible. Its soluble salts are excellent tests for the presence of sulphuric acid, which they indicate in solution by a white precipitate insoluble in water and in acids. A solution of barium oxide in water, commonly termed *baryta water*, is used in France in toning albumen prints.

BARYTA PAPER.—A paper prepared with baryta, or barium chloride, and coloring matter. It has a fine, smooth surface, and is largely used in collotype printing. This paper is also employed in the aristotype process, as it offers a smooth surface for the gelatine or collodion emulsion, prevents it from sinking into the paper, and the coloring matter gives it a pleasing tint. It is manufactured chiefly in Germany, where it is known as Baryt-papier or Kreide-papier. A formula for its preparation is the following: †

1.

Gelatine, Heinrich's	90 grains
Barium chloride	30 grains
Distilled water	5 ounces

2.

Ammonium sulphate	15 grains
Distilled water	5½ ounces

Soak the gelatine in the water till soft, add the barium chloride, and dissolve by heat; then add solution 2 in small quantities, shaking between each addition; allow the emulsion to set; break up into small pieces; wash thoroughly, and add 7½ grains of chrome alum previously dissolved in a little water.

BASE.—In chemistry, a metallic oxide capable of reacting with acids to form a salt. Metals, when they burn, produce bases, which, if soluble in water, have properties the reverse of acids. They are soft and slimy to the taste instead of sharp. They change red litmus paper to blue, or the opposite effect to acids, which change blue to red. If a base be brought together with an anhydride, the resulting compound which is generally formed is called a salt.

* "Encyclopædia Britannica," art. Capillary Action.

† E. J. Wall in "A Dictionary of Photography."

BASEBOARD.—The foundation of the camera, carrying the lens, front, bellows, and back portion. This should be as solid as possible, consistent with portability and compactness.

BASIC.—Pertaining to a base.

BASIC OXIDES.—Oxides which react with acids to form salts.

BAS-RELIEF, basso-relievo (Ital. *basso-rilievo*).—A term used in sculpture to figures in relief, that is, raised slightly above the plane in which they stand. In photography this term is often applied to the image produced by bichromatized gelatine or other similar process, in which certain portions stand out more than others according to the relative degrees of light and shade.

BASYLE.—An electro-positive ingredient of a compound. An element is said to be *basylous* when its atoms have an electro-positive action and *chlorous* when an electro-negative one. It is believed that chemical combination may be due entirely to the force of electricity and the attractive properties between positive and negative poles. In water, for instance, the atoms of hydrogen are basylous or electro-positive and the oxygenations chlorous or negative. The chlorous elements known * are chlorine, bromine, iodine, fluorine, oxygen, sulphur, selenium and tellurium; the remainder are basylous.

BATES' BLACK.—See **Varnish.**

BATH.—A term applied to various solutions in which plates, papers or films are immersed or floated, and also to the vessel holding such solution. In chemistry, baths are arranged in six different orders of temperature.

A cold bath	33 to 60 deg. Fahr.
A cool bath	60 to 75 deg. Fahr.
A temperate bath	75 to 85 deg. Fahr.
A warm bath	92 to 98 deg. Fahr.
A hot bath	98 to 106 deg. Fahr.

The principal solutions, termed baths, used in the collodion negative and albumen paper processes, are the silver bath, also termed the sensitizing bath, the toning bath, and the fixing bath, all of which will be found fully treated upon in their respective places. These are sometimes spoken of as a "40 grain" or a "50 grain bath," which signifies that 40 or 50 grains of the chemicals are contained in every ounce of solution.

Baths, dishes, or trays, as they are usually called, to hold the solutions are made of porcelain, wood with glass bottoms, waterproof Willesden paper, Delta metal, papier maché, enameled iron, vulcanite, glass, celluloid, agate ware, etc. See **Tray.**

Glass baths are undoubtedly the best, although the most expensive and easiest broken. Porcelain baths will not resist the action of all chemicals, and those made of agate ware are not recommended for many chemical solutions. A large quantity of the vulcanite and celluloid dishes are now used. Many ingenious attachments have been made to the baths now in use for rocking the plate when in the solution, or for facilitating the raising of it.

BAY SALT.—A salt made by distilling sea-water.

BEAM OF LIGHT.—A term used in optics to denote a collection or bundle of parallel rays.

BEAUFOY'S ACETIC ACID.—A commercial acetic acid. See **Acetic Acid.**

BEAUMÉ'S SCALE.—See **Hydrometer.**

BEACH'S DEVELOPER.—A name given to a somewhat complicated formula for a pyro developer devised by F. C. Beach. It is prepared as follows:

PYRO SOLUTION.

Hot distilled water	2 ounces or 59 c.cm.
Sulphite of soda	2 ounces or 62 grammes

When cold add

Sulphurous acid	2 ounces or 59 c.cm.
Pyrogallol	½ ounce or 15·5 grammes

POTASH SOLUTION.

Carbonate of potash	3 ounces or 93.3 grammes
Sulphite of soda	2 ounces or 62 grammes
Water	7 ounces or 207 c.cm.

The different parts are dissolved separately and mixed. For a normally exposed plate take 1 drachm of each solution to each ounce of water. In case of under exposure the quantity of the potash solution must be increased.

* "The Chemistry of Photography," W. J. Harrison.

BEECHEY'S PROCESS.—An unwashed collodion emulsion process introduced by Canon Beechey. The following is the simple and efficient *modus operandi*:

Cadmium bromide (anhydrous)	200 grains
Alcohol (.805)	5 ounces

are placed in a bottle and allowed to stand for some hours. The solution thus formed is then carefully decanted, and 40 minims of strong hydrochloric acid added. Then make up

Absolute ether (.720)	9 drachms
Pyroxyline	10 to 12 grains

Add to this ½ ounce of the first mixture, and sensitize by dissolving 40 grains of silver in an ounce of alcohol (.820) and adding to the collodion. The best method of effecting this is to pound up the silver nitrate in a mortar. Place this in a test tube and add to it first a quarter of an ounce of the alcohol. Boil this until the alcohol becomes slightly brown; it should then be decanted off and added to the collodion. To the nitrate of silver remaining another quarter of an ounce of the alcohol should then be added, and the operation repeated until the whole of the ounce of alcohol is used, and the silver should then be completely dissolved. Between each addition of the alcohol and silver solution the collodion should be well shaken, and when all is added the emulsion should be smooth and rather thickish. Although at first transparent, the emulsion should after twenty-four hours be very opaque and creamy, and is then ready for coating the glass plates.

The glass plate is first coated or edged with a camel-hair brush round the edges of the plate with a substratum made as follows:

White of egg	½ ounce
Water	10 ounces
Methylated spirit	½ ounce
Carbolic acid	10 drops

The emulsion, which should be well shaken and filtered, is then poured on and the plates coated in the ordinary manner. When set the plate is placed in a dish of distilled water until all greasiness is removed. It is then immersed in a dish containing beer, to which an ounce of pyrogallic acid has been added, to act as a preservative. The exposure is about twice that necessary for a wet plate. Between exposure and development the plates should not be kept longer than seven or eight days, as after that period they appear to lose brilliancy.

BEER PRESERVATIVE.—See **Preservative.**

BEER PROCESS.—See **Albumen Beer Process.**

BEESWAX.—The wax of bees, used by them in constructing their cells. This is melted down, purified, and sold as an article of commerce. Beeswax should melt at about 65 deg. C It is partially soluble in alcohol and ether, and totally soluble in chloroform. White wax is the substance bleached by exposure to light and air.

BELLOWS.—That part of the camera which connects the front and back portions. The following instructions for making camera bellows are likely to be useful:

First, with regard to the material to be used. Russia leather is the best for a camera bellows, but, of course, the most expensive. Instead of this, however, an india-rubber cloth, stiffened with best quality brown paper, will answer the purpose very well, and possesses several good qualities. It does not become mildewed, nor is it liable to be attacked by insects. It will stand summer heat very well, but in a hotter climate than ours it would be useless, as the excessive heat would soften the rubber, and the folds of the bellows would be sticking together. To make it, glue the india-rubber cloth to the best brown paper attainable, and work it together in such a manner that they are in close contact all over, and no creases or air-bubbles left between. Instead of this a black leatherette paper can be used; it is obtainable from any dealer in bookbinders' materials. This is mostly used in the cheaper make of cameras sold in the market.

The size of the paper differs, of course, with the dimensions of the camera to which the bellows is to be fitted. We will first give the dimensions of a plain half-plate camera bellows. we say plain, because there are three forms, *i.e.*, plain, conical, and truncated cornered.

It will be as well that a model of the bellows be first planned out on a sheet of paper, then creased and folded so that the operator may become familiar with the necessary manipulations and peculiarities of the folds and manner of folding.

For a bellows for a half-plate camera we require a piece of leather or paper 26 in. by 22 in. We next proceed to mark it on the inside surface by drawing a number of lines ⅞ in. apart lengthwise. (See Fig. 64.) Then four lines across at distances of 4½, 5, 7, 5, and 4½ in. respectively, representing the four corners. On either side of these four lines rule, at a distance of ⅞ in., dotted lines as a guide for the interlacing diagonal lines, as shown in the accompanying

illustration. The spaces marked A B C represent the bottom sides and top respectively, the bottom side being divided, and an allowance made for the lap.

First fold all the ⅞ lines backward and forward until the whole has the appearance of a fan. Care should be taken that every fold is neatly and carefully made, otherwise your bellows when completed will assume a very unsightly appearance. Place, when folded, between the jaws of a carpenter's bench, and screw up tightly, If a carpenter's bench is not handy, apply pressure by any other means you can think of. When this is done lay it out flat, and fold it across the four lines, they being inside. The laps are then glued together by securing one end of a long, flat piece of wood in a vise, and then sliding the bellows over it, allowing the lap to rest over the wood. Glue together, and a slight pressure will secure a permanent light-tight joint. If the laps when placed together form too thick a joint, it is as well to thin them with a sharp penknife.

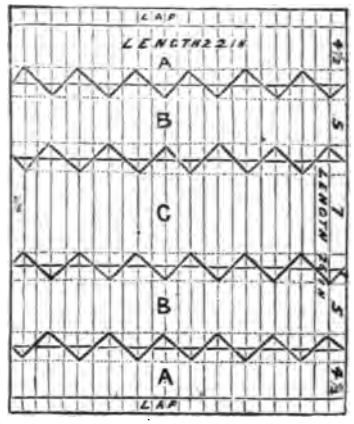


FIG. 64.

When the joint is perfectly dry, we have to form the bellows. This is accomplished by folding the diagonal lines inside in such a manner that the outer surfaces touch each other, continuing the manipulation of each corner of each separate fold singly; as the folds are made they should be well rubbed down with a piece of smooth wood or bone handle in order to give a sharp and permanent edge. If the previous operations have been carefully undertaken, it will be quite surprising to the operator to find how easily these folds can be made to harmonize.

The inside of the bellows should then be coated with a dead black, composed of either lampblack, French polish, or shellac, dissolved in water by the addition of borax or ammonia, and lampblack added thereto.

The form of bellows already described is a plain one—that is to say, the front and back are of the same size. The following is a description of the method of making a conical bellows*:

Fig. 65 gives the plan of laying out the lines for the folds. It is similar to the first except that special compensation has to be made for the gradual tapering of the bellows, the width of one-half of the folds being proportionately narrower than the other half. The size given is for a 10 x 8 camera. The size of the sheet of leather or paper required is 38 x 24 inches. In the accompanying drawing the single black lines represent the lines to be folded on the outside and the double lines for the inside folds. Securing our material we cut it to the size required, *i.e.*, 24 x 38 inches, and first draw a centre line in the direction of the length of the bellows.

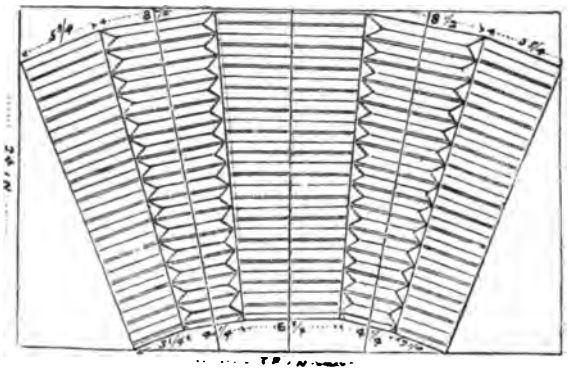


FIG. 65.

Then our bellows is to measure 10½ inches at the back and 6¾ inches in the front. We calculate half this measurement on either side of the centre line, and then connect the ends of the two front and back cross lines, the oblique lines forming the two upper radical corner lines of the bellows. The sides are to measure 8½ inches at the back and 4½ inches at the front. We again divide the distance at each end, and locate the side centre lines. From these we can easily determine the location by measurement of the two lower radial corner lines of the bellows. The bottom of the bellows is then divided, and one-half added to each side of the sides of the bellows, an extra half-an-inch being allowed for the lap or joint. The crease lines for the folds are next determined by first dividing off on the respective centre lines, in equal distances, the width of a double fold, which may be about 1½ inches. The measurement should commence from the wide end, and proceed toward the small end. Cross-fold lines are then drawn between the four radial corner lines in each section at right angles to their respective centre lines, and will meet each other, producing a shape similar to a portion of octagon. The next step is to locate the position of the intermediate fold. This is done by laying the base of a draughtsman's triangle on the base line or back line, and drawing a line at 45 degrees inward from the intersection of the corner line with the back line nearly across the fold, then by reversing the position of the triangle, so that its base is coincident with the next fold line, and drawing another diagonal line at 45 degrees inward from the intersection of the fold line with the radial corner line to where it will cross the other diagonal line. Where they meet will be the proper location of the intermediate fold line. This will be the same for all the intermediate folds. The points for these should then be located on the centre line, and they

* *Scientific American.*

should be drawn parallel with the other fold lines between the two centre corner lines. Each side of the bellows is measured off in this manner, the corner folds being located by drawing lines three-quarters of an inch distant from the corner lines parallel with the latter, and crossing the squares so formed by diagonal lines which represent the zigzag lines of the corner folds. In finding out the position of these various lines, dividers or any pointed instrument must not be used, as it is likely to make small holes in the material.

The third and last method of bellows making which we will describe is that devised by Mr. Bierstadt, and called the truncated cornered pyramidal bellows, for the reason that the corners of the folds are truncated. The advantage that this form possesses over any other is that it may be folded up into smaller space than others, and at the same time it is so elastic that its folds do not adhere to each other.

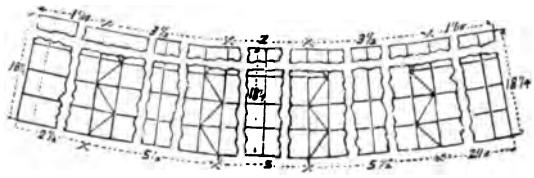


FIG. 66.

In Fig. 66 will be seen a plan of a bellows of this form for a 4x5 camera. The peculiar manner in which this kind of bellows is folded is best explained by Fig. 67. The inside measurement at the back is five inches, and at the front three inches. We draw a centre line C and measure off the side corner line D; we then divide the centre line into inches, and draw lines parallel to A, extending them on either side as far as line B. We next determine the position of the intermediate line I by deducting from half the distance between E and A the amount of space between G and H, obtained by dropping a line from the intersection of fold line E with corner line D to the base line A, the said line E F being parallel with the centre line C. Just here is an important difference. Instead of stopping the intermediate line at the corner line D, we extend it to point J, or a distance beyond the perpendicular line I F, equivalent to the space between I and F, or between E and I. We then draw the line J parallel with corner line D, and have a guide where to draw the zigzag lines like A and E to line D. By drawing a diagonal line from H to J across the square K, and from J to E across the square L, we have the proper location and angle for the corner crease lines. From the point H we measure off half the width of the inside of the intended side of the bellows. Draw a centre line perpendicular to its base, and measure off on that the position of the fold lines as described for the top of the bellows. It will be noticed that on the sides of the bellows the intermediate lines stop at J, while the other fold lines cross the line J, and meet at E. By this method a curious skew shape of the cross lines, especially between lines D and J, is observed, but is necessary in order that the folds may come out in unison. A bellows constructed after this plan requires a little more leather, but is far superior in appearance to any other.

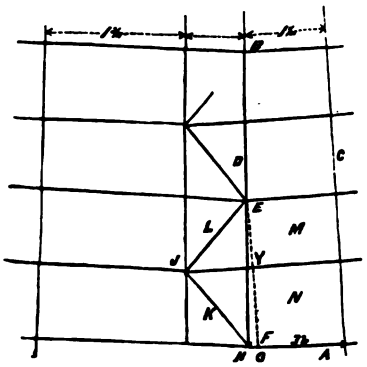


FIG. 67.

BELLOWS CAMERA.—See **Camera.**

BENGAL ISINGLASS.—See **Agar Agar.**

BENZENE (Formula, C_6H_6; molecular weight, 78; synonym, *benzole*).—This substance was derived from gum benzoin, hence the name benzole, a term still adhered to by many. In scientific literature, however, the name benzene has been universally adopted.

Pure benzene is a colorless, mobile, volatile, highly refracting liquid. It is scarcely soluble in water, but very soluble in ether, chloroform, alcohol, and glacial acetic acid. Its chief uses in photography are based upon its property of dissolving caoutchouc, asphaltum, gums, resins, fats, iodine, sulphur, oils, phosphorus, wax, amber, and most of the natural alkaloids.

It burns with a luminous flame, and its vapor is highly inflammable. Considerable care must be taken when using it, as hard friction can develop sufficient heat to inflame benzene vapor, especially if the surface rubbed be varnished with shellac. An iron heated to below red heat will also serve to ignite the vapor. These facts are not generally known, and many accidents have already resulted from ignorance upon the subject. Benzene vapor will also, if inhaled, produce giddiness and final insensibility.

The preparation of benzene is described as follows: Coal tar is distilled and freed from phenols. It is then rectified in an iron boiler so constructed that pure benzene passes over, while its homologues condense and run back to the boiler. Commercial benzene often contains traces of alcohol. It may be rendered more anhydrous by placing a quantity of freshly prepared calcium chloride in the bottle which contains it. After twenty-four hours, during which time it should have been shaken freely, it may be used.

BENZENE VARNISH.—See **Varnish.**

BENZOIC ACID (Formula, $C_7H_6O_2$; molecular weight, 122).—Obtained from gum benzoin by sublimation, or by extracting with acetic acid, or by the oxidation of benzylic alcohol by aqueous chromic acid.

Benzoic acid takes the form of light, feathery, colorless crystals, melting at 121 deg. Fahr. It dissolves sparingly in cold, and moderately in hot water, and also in alcohol. It is sometimes recommended as an addition to the toning bath, and has also been employed for surfacing papers.

BENZOLE.—See **Benzene.**

BENZOLENE.—A mixture of benzene—naphtha and benzene is sold under this title. It is used as a solvent for caoutchouc and for removing grease-spots from clothing, etc. It is, however, highly inflammable and must be used with caution. Its vapor forms with the air an explosive mixture. To distinguish benzolene from benzene drop a piece of bitumen in it; benzene will dissolve it, benzolene not.

BI.—A prefix used in chemistry to denote that two atoms of any substance, such as chlorine, sulphur, etc., are united to an element, as bichloride of mercury, $HgCl_2$. Where the word began with a consonant the prefix was changed to bin, as binoxide.

NOTE.—Instead of **bi** the prefix **di** is now often used, although it will no doubt be long ere the older terms fall entirely out of use.

BICARBONATE OF POTASH.—See **Potassium Bicarbonate.**

BICARBONATE OF SODA.—See **Sodium Bicarbonate.**

BICHLORIDE OF MERCURY.—See **Mercuric Chloride.**

BICHLORIDE OF PLATINUM.—See **Platinous Chloride.**

BICHROMATE DISEASE.—A cutaneous disease produced by prolonged and frequent handling of potassium dichromate, whether dry or in solution, or by allowing the solution to enter a scratch or abrasion of the skin. In the first case it takes the form of a thick red rash, which, if closely examined, shows minute watery particles, accompanied by violent irritation. The skin then becomes destroyed, dries up, and exfoliates in bran-like scales. In winter time, when the hands are chapped, they are much more easily affected. The disease is usually confined to the back and sides of the hand and fingers. The hard portions of the palm remain unaffected. If the skin be free from scratches, cuts and abrasions, only a prolonged and constant working with bichromate will produce the disease. There are several remedies, though the prevention by wearing india-rubber gloves is better than any of them. Make up a preparation of

Glycerine	1 ounce
Carbolic acid	20 to 30 drops
Water	6 ounces

Rub this well into the skin, and wash the hands frequently during the day with carbolic soap. Before bedtime apply strong nitrate of mercury ointment. By following this treatment up for several days, and carefully avoiding handling the bichromate, except with india-rubber gloves, no ill effects will be experienced.

If the disease be caused by the solution penetrating a scratch or abrasion of the skin, the matter is more serious, and should be attended to at once. A smarting sensation will be felt, when the hands should be well washed under a tap and the poison sucked out. If after a little time the smarting sensation is resumed, the hands should be placed in warm water, and afterward in dilute ammonia for a few minutes. This should be followed by poulticing. If these precautions are not taken it is possible that an ulcer may form, which will eat deeply into the flesh, defying all efforts of cure. It is stated that the citrine ointment of the pharmacopœia has proved an effectual remedy.

BICHROMATE OF AMMONIA.—See **Ammonium Bichromate.**

BICHROMATE OF POTASH.—See **Potassium Bichromate.**

BICHROMATE RAY FILTER.—A cell containing a solution of bichromate of potash placed in front of the lens in order to strain out the actinic blue rays and weaken their action upon the sensitive plate. The cells as now made consist of two plates of optical glass perfectly polished, between which is cemented a glass ring three millimeters thick, the inner surface of the ring being ground to prevent reflections, and two holes being drilled about a centimeter apart through which the cell is filled or cleaned. The cell is mounted in a nickeled mounting lined with cork, and slips on the hood of the lens as a cap would (Fig. 68). It is usually employed with orthochromatic plates and is especially useful in securing cloud effects, *q. v.*

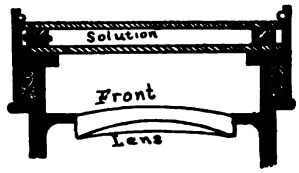


FIG. 68.—BICHROMATE RAY FILTER ATTACHED TO THE LENS.

BICHROMATE REDUCER.—See **Reducer.**

BICOLORED.—A photograph is said to be bicolored when it presents two colors to the eye. This effect often takes place in toning. The weaker portions of the image, being attacked with greater force by the gold, take a different color to the stronger parts. A bicolored image is the result.

BICONCAVE.—A term applied in optics to lenses having two sides concave or hollowed out. Synonymous terms, *double-concave*, *concavo-concave*. See **Lens.**

BICONVEX.—A term applied in optics to lenses having two sides convex, or extending outward in the form of a sphere. Synonymous terms, *double-convex*, *convexo-convex*. See **Lens.**

BINARY.—A binary compound is a term used in chemistry to signify a compound containing only two elements, or of an element and a compound performing the functions of an element, or of two compounds performing the function of elements. Such compounds end in *ide*.* If, however, the two elements combine with each other in various proportions and thus form two distinct binary compounds, which is liable to cause confusion, the termination *ic* is given to the compound containing the greater proportion of the non-metallic element and *ous* to the one containing the lesser.

BINARY THEORY.—A theory that all definite chemical salts are combinations of two bodies, which may be single elements or compound elements, or one of each. Potassium sulphide is a binary compound containing the elements of sulphur and potassium.

BINOCULAR CAMERA.—See **Stereoscopic Photography.**

BINOCULAR PERSPECTIVE.—See **Perspective.**

BINOCULAR PHOTO-MICROGRAPHY.—See **Photo-Micrography.**

BINOCULAR VISION.—Vision when both eyes are employed. This term is used in contradistinction to monocular vision—a sight with one eye only. The stereoscopic effect produced by vision with two eyes is fully treated upon under **Stereoscope.** See also **Vision.**

BIOSCOPE.—An instrument described by Duborcq for obtaining a stereoscopic effect. See **Stereoscopic Photography.**

BISULPHIDE OF CARBON.—See **Carbon Bisulphide.**

BISULPHITE OF SODIUM.—See **Sodium Bisulphite.**

BISULPHITE OF POTASSIUM.—See **Potassium Bisulphite.**

BITUMEN.—See **Asphaltum.**

BITUMEN OF JUDEA.—See **Asphaltum.**

BLACK CLOTH.—A cloth used to cover the camera and the head of the operator while performing the focusing operation. It is usually made of velvet, but superior to this is waterproof cloth, as this may be useful to protect the camera in a sudden shower of rain. Another advantage is that it does not cling to the hair like velvet cloth when the head is being drawn from under it. The cloth should be of ample dimensions, and should be buttoned or otherwise fastened on to the camera front.

BLACKING.—The interior of the camera, dark slides and lens tubes and the diaphragms must be coated with a dead black color, otherwise reflected light will fog the image on the plate. A blacking for this purpose may be made by grinding lampblack into a paste with japanners' gold size. (See **Black Varnish.**) A cheap black stain for wood is the following :†

Extract of logwood	15 grammes
Chromate of potash	2 grammes
Water	1 litre

The extract of logwood is dissolved in boiling water and the chromate then added. The color of the liquid is a deep violet, which changes to a pure black in contact with the wood. The diaphragms or brasswork that undergoes much handling may be blackened as follows: Dissolve one ounce of copper carbonate in half-a-pound of ammonia solution, constantly stir, and add 18 ounces of water. The brass objects should be well polished with emery paper, and attached to brass or copper wires and plunged into the solution until completely blackened. They are then rinsed in water, dried in sawdust, and varnished with an oil varnish considerably diluted with spirits of turpentine.

BLACKLEAD (Synonyms, *graphite* and *plumbago*).—Carbon containing about five per cent. of quartz, with oxides of iron and manganese as impurities. It contains no lead whatever. Besides its use for blacking purposes, it is an excellent lubricant for woodwork. The movable parts of the camera will be found to work much easier and smoother with its use.

* With the new system of nomenclature adopted by chemists the final *e* is omitted.

† From *Science en Famille.*

BLACK MIRROR.—A piece of black glass with an optically plane surface and highly polished; also known as a Claude Lorraine mirror. It is recommended for photographing clouds by reflection. A piece of plate glass coated at the back with a black varnish can also be used if care be taken to avoid the secondary image formed by the reflection of the surface of the glass. A black mirror is also useful for viewing landscapes to get a better idea of the ultimate result in the photographs of scenery seen as monochrome images.

BLACK STAIN.—A dead black stain for the interiors of cameras, plate-holders, etc., can be made with

Gum shellac	1 ounce
Borax	½ ounce
Glycerine	½ ounce
Water	1 pint

When dissolved, add 2 ounces of aniline black soluble in water.

BLACK SPOTS.—A source of great annoyance to the photographer. In the negative they are sometimes due to dust spots settling on the plates after coating and before having dried. In the silver print they are usually due to fine metallic particles in the paper. They may also be caused by foreign matter floating about the air of the workrooms and settling on the plates or paper when in a moist and sensitive state.

BLACK TONES.—For methods of obtaining black tones with silver prints, see **Toning.**

BLACK VARNISH.—See **Varnish.**

BLANCHARD'S BRUSH.—Made by fastening a piece of swan'sdown calico or common flannel, by means of an india-rubber band round a strip of glass or wood two inches wide and six inches long (see Fig. 69), and is a useful instrument for coating plates with albumen or for similar purposes. It was used in the collodion process for coating plates with a substratum.

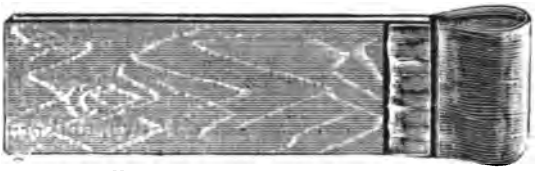


FIG. 69.—BLANCHARD'S BRUSH.

BLEACHING.—Before attempting to photograph engravings or old prints that have become yellow, it is well to bleach them in the manner to be described. Unless this be done, or isochromatic plates be used, the yellowness of the paper will have in the finished print a dark and unsatisfactory appearance.

The engravings or prints to be bleached should be laid in oxygenated muriatic acid, and there allowed to remain until the yellowness has diappeared. They are then thoroughly washed in several changes of water to remove the acid and its attending disagreeable smell.

The process of whitening the negative with bichloride of mercury previous to intensifying (*q.v.*) is also termed bleaching. This process is also used in the making of outline sketches from photographs for illustration. The outlines of the silver print fixed but untoned are traced with a waterproof ink and the whole inserted in the bichloride of mercury bath, which bleaches the image, leaving the line sketch ready for making a rapid zinc cut.

BLEACHING POWDER, or calcium hypochlorite, is prepared by passing chlorine over slaken lime. It decomposes rapidly and in different ways by keeping. Its uses in photography are based upon the fact of its containing chlorine in such a loose form that any acid will liberate it. See **Calcium Hypochlorite.**

BLIND SHUTTER.—An instantaneous or time shutter, working in the form of a blind, passes across the lens or the plate. See **Shutter.**

BLISTERS.—Blistering of the film is an annoying defect which occurs with plates and papers coated with gelatine, collodion or albumen. Films of this nature expand on being wetted, so that the probable cause of the formation of blisters is due to the non-adherence to the glass or paper of certain portions of the film. It is also probable that blistering is due to the generation of carbonic acid gas underneath the film when treated with the hypo bath.

In the albumen process blisters generally make their appearance in the prints while in the fixing bath or in the first washing water, sometimes due to a strong saline solution being shut in between the albumen and the paper support, and which is afterward brought into contact with water. Papers which have received a double or treble coating of albumen are most liable to blister. Blistering in albumen prints is often caused by rough washing, in which the prints are subjected to severe handling or tumbling, and also to a gas being formed by the decomposition of organic matter. The best known remedy is the use of all solutions used in the toning, fixing, and washing operations at a certain temperature, and the addition of a little common salt to the first washing water. If the blistering is very bad, the prints should be plunged immediately after fixing into a saturated solution of common salt, or the following:

Table salt	1½ pounds
Ammonia	360 grains
Water	1 gallon

In this solution the prints should be floated face downward for about ten minutes, and afterward thoroughly washed. W. H. Sherman recommends the use of a salt solution followed by immersion in a 5 per cent. solution of carbolic acid.*

The following remedies against blistering of albumen paper are given :†

Do not dry the paper by excessive heat. Avoid acidity in solutions. Moisten the prints before washing with a sponge saturated in alcohol. Immerse the prints before fixing in a weak alum bath. Add a trace of ammonia to the fixing bath. Add one-tenth part of alcohol to the ordinary toning bath.

Gelatino-bromide papers are also liable to blister. If during the summer, the temperature of the solutions must be lowered. Blistering with this kind of paper can be cured by laying the prints for a few minutes in a solution composed of 10 grains of chrome alum dissolved in 4 ounces of water, and another 4 ounces of alcohol added. If the blistering is not very bad, the prints may be laid in methylated alcohol only. The addition of 1 drachm of the following to each ounce of fixing solution is also a preventive of blisters :

Sulphate of aluminium	3 ounces
Water	24 ounces

This solution should be well shaken and then allowed to stand until clear.

Blisters are often caused by the presence of foreign substances, such as lime, in the water. In this case the water should be boiled for about fifteen minutes before using.

With developed papers of this kind the method of adding a little methylated spirit to the developer (about 5 per cent. will suffice) may often be the means of preventing blisters.

Blisters with dry plates may be avoided by immersing the plate immediately upon the first signs of their appearance into methylated spirit, or into a saturated solution of chrome alum, or a weak solution of formic aldehyd.

BLOCKING-OUT —A term used in printing from the negative. When certain portions of the negative are not required to be reproduced in the positive, they are blocked out with an opaque paint of some kind applied to the face or back of the negative. In blocking out skies when the horizontal line is sharp no difficulty will be experienced, but when trees or branches project, the blocking should be done by dabbing or stippling the color on the back of the negative.

BLOCK PRINTING PROCESSES.—With this term is included all those processes in which, by the aid of photography, a block is produced, capable of being printed from in an ordinary printing press together with the letter-press. To accomplish this the half-tones of the photograph must be broken up into lines, dots, stippling or grain. The principal processes described here are Meisenbach's process, Ives' process, Husnik's process, Mosstype, and Dallastype. See, also, **Photo-engraving** and **Enamel Process.**

BLOOD ALBUMEN.—See **Albumen.**

BLOTTING PAPER.—A thick, bibulous, unsized paper capable of imbibing superfluous solution from anything laid against it.

Particular attention should be called to the necessity of using the purest chemically clean blotting paper when required for drying silver prints. In the manufacture of the cheaper qualities large quantities of hyposulphite of soda are used. This is of course detrimental to the keeping powers of the silver prints laid in contact with it. The blotting paper used should also be changed as often as consistent with economy, as it soon becomes saturated with foreign matter that is likely to damage the pictures.

BLUE-BLACK TONES.—See **Toning.**

BLUE GLASS.—Blue glass has often been recommended for the studio to modify the glare of the light and relieve the eyes of the sitter. By its use the exposure is slightly increased. Other methods of reducing and softening the light are given under **Studio.** A piece of blue glass is useful in viewing a landscape and obtaining some idea of the effect when practically reduced to monochrome.

BLUE PRINTING PROCESS.—See **Cyanotype.**

BLUE TONES.—See **Toning.**

BLUE VITRIOL.—See **Copper Sulphate.**

BLURRING.—An image is said to be blurred when it possesses a double or indistinct outline. This indistinctness may be caused by the movement of the camera or the object during the exposure. When photographing on a windy day it is often advisable to steady the camera by suspending a large stone tied to a piece of cord fastened to the centre of the tripod. The stone should hang as near the ground as possible without touching it. Another cause of blurring, or

* PHOTOGRAPHIC TIMES, Aug. 31, 1894. † "American Annual of Photography."

double image, is the use of a shutter having a double motion during exposure. Much care should be taken when purchasing an instantaneous shutter of this description that when employed to work at the highest speed no jarring or jerking takes place, as this will invariably give a double image by shifting the camera during the exposure. Blurred images may also be caused by **Halation** or by **Aberration**, *q.v.*

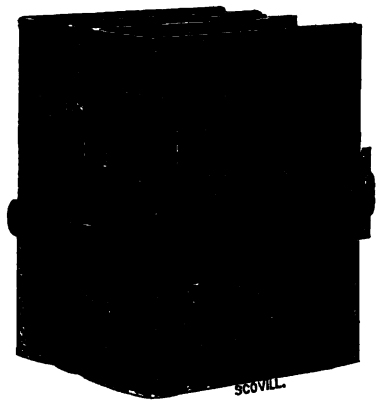


FIG. 70.—BOOK CAMERA.

BODY.—A term applied to substances in allusion to the quantity of solid substance they contain. We have papers without body, *i.e.*, too flimsy; photographs without body, in contradistinction to those which have plenty of reduced material and vigor.

BOILING.—Boiling gelatine emulsion to procure increased sensitiveness was first discovered by Bennett, an amateur, in 1878. He found that by boiling or long continued heating gelatine emulsion gradually assumed the granular state and became exceedingly sensitive to light. The emulsion is not usually boiled, but heated to a certain temperature for several hours, according to the degree of sensitiveness required (see **Emulsion**).

BOILING POINT.—The temperature at which liquids are converted into vapor with ebullition. The boiling point of water is 212 degrees Fahr., of alcohol 176 degrees, of ether 96 degrees, and of mercury 662 degrees.

BONE BLACK.—See **Charcoal.**

BONE GELATINE.—See **Gelatine.**

BOOK CAMERA.—A detective camera disguised by being made in the form of a book or a number of books bound together (see Fig. 70) so as to attract as little attention as possible.

BORACIC ACID.—See **Boric Acid.**

BORATE OF SODIUM.—See **Sodium Borate.**

BORAX (Formula, $Na_2B_4O_7 + 10H_2O$. Synonyms, *sodium biborate*, *tinkal* or *tincal*).—An exceedingly useful salt, found native in Thibet, California and Peru, also in certain parts of Italy. In the region of hot springs and volcanic action, about 65 miles northwest of Suisan Bay, California, and about 36 miles from the Pacific Coast, is situated a clear lake, now called the Borax Lake. Its water contains 2,401.56 grains of solid matter per gallon, of which 535 is crystallized borax. Borax crystals are deposited in large masses in the bed of the lake, and are obtained by sinking caissons, pumping out the water, and digging up the deposit.

According to the method of manufacture, two varieties of borax may be obtained, namely—

Prismatic borax.....Formula—$Na_2B_4O_7 + 10H_2O$
Octahedral borax .....Formula—$Na_2B_4O_7 + 5H_2O$

Artificial borax contains many impurities, such as sodium carbonate, small quantities of sulphates, chlorides, calcium, and magnesium salts. It is also adulterated with alum and common salt.

Pure borax should form transparent colorless crystals slightly efflorescent and having a weak alkaline reaction.

Borax is readily soluble in water; 100 parts of water heated to a temperature of 100 degrees Fahr. dissolve 201.5 parts. An aqueous solution of borax has a slightly alkaline reaction. It is also soluble in glycerine, but insoluble in alcohol.

The use of borax in photography is mostly confined to the toning process. It also acts as a restrainer in development with pyro, and as an accelerator with eikonogen and hydroquinone.

BORIC ACID (Synonyms, *boracic acid*, *orthoboric acid*; formula, H_3BO_3; molecular weight, 62).—Boric acid is a bibasic acid, found in a free state in many volcanic districts, or it may be produced by treating a solution of three parts of borax dissolved in twelve parts of hot water with one part of sulphuric acid, or by making a strong solution of borax in hot water and adding hydrochloric acid until an acid reaction takes place. When cooled the boric acid crystallizes out, and should be washed with cold water and dissolved for use in rectified spirit. Crystallized boric acid is in colorless crystals, soluble in water, alcohol and volatile oils. It is sometimes employed as an antiseptic, and its addition to combined toning and fixing baths has been recommended by Gaedicke.*

BOSTON MAT.—This name has been given to a form of lantern slide mat specially designed by W. G. Reed, of Boston, Mass. Fig. 71 will show the design. One of the advantages claimed for it is the necessity for absolute register. Mercantile slide plates are labeled 3¼ x 4

* See PHOTOGRAPHIC TIMES, Feb. 9, 1894.

inches. As a matter of fact they are seldom of exact size, and the variation often exceeds ⅛ of an inch larger or smaller, either way. By first trimming on the dotted line which is to be on top when the slide is held upright, and then cutting the opening equally on each side of the central marks, the horizontal center line will always be thrown on the same place. To bring the perpendicular center in the same place:—First trim the left hand end of the mat by the dotted lines; that is exactly two inches from the center; cut the sides of the opening equidistant from the center; then by replacing a "stop" on the lantern or carrier, all slides so matted will "register." The lines serve as a guide for cutting out any size of opening to suit the subject. This is, of course, far preferable to employing the same size of opening for every subject.

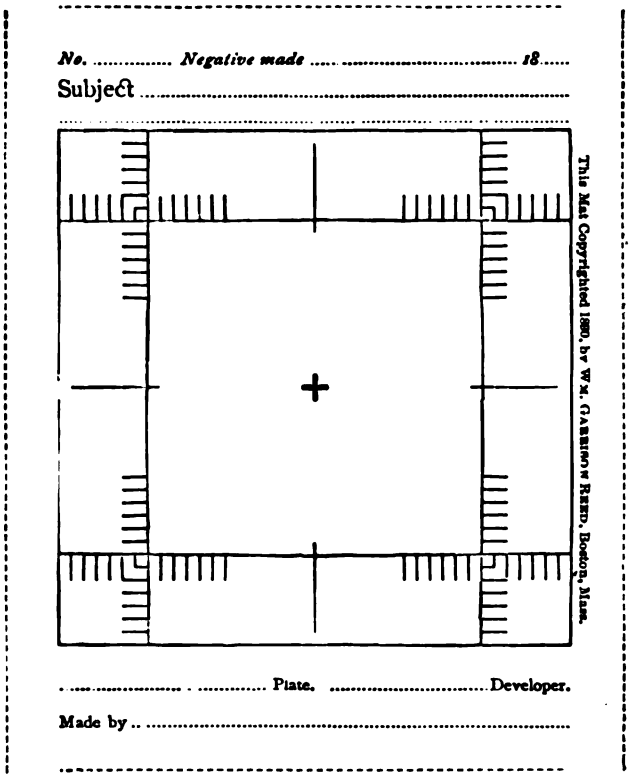


FIG. 71.—BOSTON MAT.

BOTTLES.—The selection of convenient bottles for the various chemicals used in photography requires some little thought. Acids should be kept in glass-stoppered bottles (Fig. 73), and the stoppers rubbed round with a little vaseline. This renders the stopper perfectly air-tight, and prevents it from becoming fast in the bottle. The same applies to ammonia, and other volatile compounds. Fluoric and other glass-destroying acids should be kept in bottles made of gutta-percha. Solids should be kept in bottles, with wide mouths (Fig. 72) to facilitate the removal of large lumps. For coating with gelatine or collodion emulsions, the substance should be placed in a convenient bottle. The most suitable are the hock or Rhine-wine bottles, for the reason that the long and gradually sloping neck prevents the formation of air bubbles. Their non-actinic color renders them especially suitable for sensitive emulsions.

All chemicals sensitive to light should be placed in yellow or non-actinic colored bottles.

For convenient dropping bottles, see **Dropping Bottle.**

FIG. 72. FOR SOLIDS.

FIG. 73. FOR ACIDS.

BOUDOIR.—This name has been given to a standard size for portrait work. Boudoir mounts measure 5¼ x 8½ inches.

BOXES.—For storing unexposed plates these should be perfectly light-tight, and made of such wood or material as will not affect the most sensitive plates. To prevent the plates from coming into close contact with each other the boxes are usually fitted with grooves into which the negatives slide. Fig. 74 shows the usual style of boxes employed for storing plates, negatives or lantern slides.

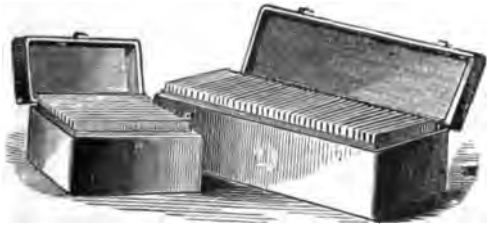


FIG. 74.—NEGATIVE OR LANTERN SLIDE BOXES.

BRASS WORK.—The brass work of the interior of the lens and the diaphragm stops should be kept a dull black, to prevent the reflection of light upon the sensitive surfaces. For a suitable black, see **Blacking** and **Black Varnish.**

BREADTH.—This term is used by artists to denote the proper balance and relative value that should exist between the lights and shades of a picture. To secure breadth, a principal part must be made predominant, and parts that are secondary should be kept in due subordination, and thus detail in its technical sense is opposed to breadth.

BRENZCATECHIN.—See **Pyrocatechin.**

BRILLIANCY.—A desirable quality in a negative. It is said to be brilliant when it possesses a bright, pleasing contrast between the lights and shades without hardness or lack of medium tones. Correct exposure and careful development are required to secure brilliancy.

BROKEN NEGATIVE.—With a little care and trouble passable prints may be made from broken negatives if the glass only is cracked or broken. If the film is broken, however, it is almost useless to endeavor to hide the defect. Even with a cracked negative it is usually less trouble to make a new negative than to print from the broken one. As this is not always possible, however, it will be well to give the two methods of printing so as to partially hide the defect. First method—Place the negative and sensitized paper in the printing frame as usual. Lay or attach a piece of tissue paper over the back of the negative or glass of the printing frame, and lay the frame on a board suspended by the four corners to a roasting jack. The object of this is to keep the printing frame continually turning round during the printing operation. If a meat jack is not obtainable the ingenuity of the operator will easily suggest some similar arrangement. Second method—Lay the printing frame in a narrow box about two feet deep, having its sides blackened. Next drop a piece of tissue paper or lay a piece of ground glass over the frame. By this means only direct light from above will attack the silver paper, no side light being admissible, so that the crack or line of break in the glass will not be so distinctly defined.

BROMHYDRIC ACID.—See **Hydrobromic Acid.**

BROMIDE.—The principal bromides used in photography are potassium and ammonium bromides. Of these two, potassium bromide is the most suitable, owing to its stability.

Ammonium bromide is hygroscopic, and discolors under the action of light. Nearly all bromides contain a slight trace of chloride. If the quantity does not exceed 1 per cent., however, and soluble bromide be in excess of the silver, its presence in emulsions is of little consequence; but if the bromide and silver be used in exactly their combining proportions, or if silver be in excess, silver chloride will be formed.

To detect a bromide in the presence of an iodide or chloride, first add a small quantity of sulphuric acid to the solution, then starch paste, and lastly, a few drops of nitric acid. Next gradually drop in chlorine water until the blue color formed by the starch paste is destroyed, and continue the addition of the chlorine water until it is present in slight excess. Lastly shake up with chloroform. This will dissolve any bromine present, forming a yellow or yellowish-brown precipitate.

BROMIDE EMULSION.—See **Emulsion.**

BROMIDE ENLARGEMENTS.—See **Enlarging.**

BROMIDE OF AMMONIUM.—See **Ammonium Bromide.**

BROMIDE OF ARSENIC.—See **Arsenic Bromide.**

BROMIDE OF BARIUM.—See **Barium Bromide.**

BROMIDE OF CADMIUM.—See **Cadmium Bromide.**

BROMIDE OF CALCIUM.—See **Calcium Bromide.**

BROMIDE OF COPPER.—See **Cupric Bromide.**

BROMIDE OF POTASSIUM.—See **Potassium Bromide.**

BROMIDE OF SILVER.—See **Silver Bromide.**

BROMIDE OF ZINC.—See **Zinc Bromide.**

BROMIDE PAPER.—A paper coated with a gelatino-bromide of silver (described under **Emulsion**, *q.v.*) and used for enlargements or printing by contact. This paper, of which there are several kinds, may be obtained having a smooth or a rough surface, the latter being most suitable for enlargements. It should be mentioned that there are two distinct kinds of bromide papers—*negative* bromide paper, a paper coated with the same kind of emulsion as used for plates, and employed in the camera for negative making, and a *positive* emulsion paper coated with an emulsion a little less sensitive to light. The following is a descriptive method of using the positive paper.

The exposure varies, of course, with the density of the negative and the quality and intensity of the light which varies inversely as the square of the distance from the radiant to the recipient. For a properly developed and correctly exposed glass negative, one second by diffused daylight, or ten seconds at a distance of one foot from an ordinary gas burner should suffice. An oiled paper negative requires about double this exposure, and an unoiled paper negative about five times the amount. Over- or under-exposure may be judged of upon development. An over-exposed print will present a poor and flat appearance, devoid of vigor in the shadows, and having an excess of half-tone, while a want of half-tone and a dark, heavy appearance of the shadows is due to under-exposure. As soon as the correct exposure is ascertained, any number

of prints may be made without fear, for if the paper, negative, light, distance and exposure be the same in each case, the results must likewise be similar, and a large batch may be developed at one and the same time.

Developing is the next operation. The ferrous-oxalate developer gives the best results. Two formulae will be given.

FERROUS-OXALATE DEVELOPER.

No. 1.

Oxalate of potash	16 ounces
Hot water	48 ounces

No. 2.

Iron protosulphate	16 ounces
Hot water	32 ounces
Sulphuric acid	½ drachm

No. 3.

Potassium bromide	1 ounce
Water	32 ounces

Solution No. 2 should be tested with blue litmus paper, which it should redden distinctly. If this effect does not take place, a very slight addition of sulphuric acid will probably suffice. These three solutions should be kept separately, and only mixed when required for immediate use, when they should be taken in the following proportions:—No. 1, six ounces; No. 2, one ounce; and No. 3, one drachm, mixed in the order given.

Many modifications of this developer have been recommended, and consist chiefly in the addition of citric acid (about 1 drachm) to the oxalate solution (No. 1), and the substitution of the same quantity of the same acid in place of the sulphuric acid in the iron solution (No. 2)

Another developer to be recommended is the hydrokinone developer. In twelve ounces of hot water dissolve

Sodium sulphate	1 ounce
Hydrokinone	15 grains
Sodium carbonate	1½ ounces
Potassium carbonate	1½ ounces
Potassium bromide	20 grains

For sepia or brownish tones use an alkaline pyro developer, arranged as follows:—

Water	1 ounce
Pyrogallic acid	1 to 2 grains
Ammonia	2 minims
Potassium bromide	3 grains
Citric acid (sat. sol.)	10 drops

After exposing the paper it is placed in a bath of cold water until limp. It is then removed and placed face upward in a tray, and the developer poured rapidly over it. The image should appear slowly, and should be strong, clear and brilliant, exhibiting, if correctly exposed, all the detail in about three minutes. The dish should be kept rocking: many ingenious contrivances having been made to do this automatically, although the hand supersedes them all. All air-bells should be removed from the film before the development has proceeded far, and when the shadows are sufficiently black the developer is poured off and the clearing solution added. In developing it should be remembered that a too rapid development gives a weak, flat image. A too slow development gives violent contrasts and great hardness. The addition of a further quantity of No. 2 solution strengthens the developer, while No. 3 tends to retard its action. By modifying the proportions in mixing the developer much softness and brilliancy can be obtained. For developing a print from a weak, soft negative mix one part of iron to six of oxalate. No larger quantity of iron than this must be taken, as it will then form a precipitate, and the developer will be spoiled. A short exposure and a prolonged development with the above developer will give brilliant results with a thin negative. With a dense, hard negative, however, with hard contrasts, a very small portion of iron solution should be added, say 1 to 12, while for every three or four ounces of developer a single drop of the bromide solution will suffice.

When the print has obtained full vigor, the developer is poured off, and, without any previous washing, the following clearing solution is flooded over it: *

Acetic acid	1 drachm
Alum	8 ounces
Water	32 ounces

or this:

Sulphuric acid	1 ounce
Water	100 ounces

Allow this to act upon the image for about a minute, then pour it away and apply a fresh portion. Then rinse and place in the fixing bath, made up with three ounces of sodium hyposulphite dissolved in 16 ounces of water, and tested for alkalinity.

* The clearing solution is only necessary when the ferrous-oxalate developer is employed.

After fixation, the prints are thoroughly washed in many changes of water for about two hours. They are then hung up and placed across a pole to dry.

The rough or mat surface papers appear to best advantage with most subjects if allowed to dry with their ordinary surface. A brilliant glossy surface may, however, be given to bromide prints upon smooth paper in the following manner:

After the prints are removed from the final washing water, they are squeegeed in contact with a sheet of plate glass, previously well cleaned and lightly rubbed over with French chalk (a powdered talc). Here they should remain until quite dry, when they are easily peeled off the glass with a surface equal to the glass itself. Instead of plate glass, a sheet of polished vulcanite, celluloid, or even a ferrotype plate, may be used. With these, if properly cleaned, no special preparation is necessary. Bromide prints are mounted in the ordinary way. They appear to best advantage behind a cut out, or on a deep sunk mount.

If proper use of the clearing solution has been made, the pictures should be clear and free from yellow stains, the object being to remove these by preventing the precipitation of the iron from the developer in the paper. Over-printed proofs may be reduced by immersion in chlorine water or in a solution of cupric chloride. If blisters appear in fixing, a little common salt should be added to the first washing water, or the prints placed in a three per cent. aqueous solution of chrome alum. The most scrupulous cleanliness must be observed with regard to the dishes used, and, in fact, with everything with which the paper comes into contact, as the faintest trace of hyposulphite of soda, pyro or free silver, will ruin the pictures entirely. The tray used for the oxalate development should not be used for any other purpose.

The tone of the prints upon bromide paper differs considerably with the different manufactures of paper, and with the various methods of development. Agreeable tints may be obtained by the usual method of toning with chloride of gold. Bromide prints may also be toned with platinum by substituting it for the silver image. The prints should be very much over-printed and then soaked in the following bath until the desired tone is secured:

Platinum perchloride	8 grains
Distilled water	30 ounces
Hydrochloric acid	½ ounce

They are then washed and dried.

Bromide Negative Paper is a paper coated with an ordinary gelatine emulsion as used for dry plates, and described under **Emulsion.** Its treatment is the same as is required for ordinary dry plates. Owing to the opacity of the paper the printing process is much slower. Under **Translucent** will be found one or two methods of making the paper more transparent.

BROMIDE PENCILS.—Pencils specially manufactured for touching up or spotting out bromide contact prints or enlargements.

BROMINE.—A non-metallic element discovered in 1811, having the symbol Br and an atomic weight of 80. It is a dark, reddish-black liquid obtained from sea-water and from saline springs, chiefly from Stassfurt. It has a powerful and irritating smell. When inhaled it is poisonous. It is soluble in water to the extent of about 30 in 1,000. It is more soluble in alcohol, ether and chloroform. An aqueous solution is used to give off bromine vapor in the Daguerreotype. Bromine has also been added to collodion in place of iodine, but is inferior to it. It is closely analogous to chlorine and iodine, its affinities being weaker than those of the former but stronger than the latter. Bromine forms a large class of salts, of which the following are most familiar to photographers, and will be found in their respective places in this work: Ammonium bromide, barium bromide, cadmium bromide, potassium bromide, silver bromide, and zinc bromide. Bromides, with the exception of silver and mercurous bromides, are soluble in water. They can be detected by the following reactions: Silver nitrate gives a yellowish precipitate of silver bromide insoluble in dilute nitric acid, but soluble in strong ammonia. Chlorine liberates bromine from all its soluble compounds, and if the liquid be shaken up with ether a yellow etheral solution will float on the surface of the liquid. A solution of starch produces a yellowish-red color; it distills as a liquid. Bromine water followed by hypo has been recommended as a reducer for bromide prints, also for use as a hypo eliminator.

BROMIZER.—A bromide added to a collodion or gelatine emulsion is called a bromizer.

BROMO-ARGENTOTYPE.—A process in which the sensitive compound is composed of silver nitrate and a bromide, usually potassium or ammonium bromide.

BROMOFORM.—A compound analogous to chloroform, but containing bromine instead of chlorine. It is a heavy volatile liquid and is, when pure, colorless, and solidifies at 8 deg. C.

BROMO-IODIDE OF SILVER.—See **Silver Bromo-Iodide.**

BROMO-IODIZED COLLODION.—A collodion to which an iodide and a bromide have both been added.

BROMURET.—Bromide, *q.v.*

BRONZE.—In silver printing the darker portions of the positive assume, after prolonged exposure, an olive-green color, lighter than the dark-brown color which should precede it in intensity. This is called bronze, and its production bronzing. In printing with aristotype papers it is usually necessary to carry the process on until the darkest shadows show a bronze color by reflected light; on toning this disappears.

BRONZE MOUNTS.—See **Mounts.**

BRONZE PICTURES.—Pictures in bronze powders of various colors may be obtained by the powder or dusting-on process (*q. v.*).

BRONZE POWDER.—Bronze powder is made by stirring in a crucible over a clear fire equal quantities of sulphur and white tin oxide until the mixture assumes the appearance of a yellow flaky powder. This powder is largely used in place of gold leaf for edging and lettering the cheapest class of mounts. With these mounts loose bronze powder often becomes imbedded in the face, and causes small white spots to appear in the print after it has been mounted. See **Mounts.**

BRUNSWICK BLACK.—Prepared by fusing 2 pounds of asphalt and mixing thoroughly with about a pint of hot boiled oil. When the mixture is cool two pints of turpentine are added.

BRUSH TONING.—See **Toning.**

BUBBLES.—See **Air Bells.**

BUCKLE'S BRUSH.—A convenient little arrangement for spreading emulsion and for a variety of other purposes, easily made with a piece of thin glass tubing, with a diameter somewhat exceeding that of a common lead pencil. Into one end of this tube is drawn by means of a bent silver wire or piece of string a tuft of cotton wool, a good-sized tuft being allowed to remain outside to act as the brush. One of the advantages of this little arrangement is the ease with which the cotton-wool, when dirty, can be replaced.

BUFF.—A buff is used in the Daguerreotype process for polishing the silver plate, and also in glass processes for polishing the glass plate. A handbuff is made with a piece of deal about sixteen inches long and five inches wide with a handle either at the back or at one end. The deal is then covered with fine velvet, the ribs of which are laid across the buff, or, instead of velvet, chamois-leather is used.

BUNSEN BURNER.—Named after the introducer, Herr Bunsen, of the Breslau University. It consists of a gas jet surmounted by a wide brass tube, at the bottom of which are several holes for the admission of air (see Fig. 75). The air and the gas mix in such proportions that they burn with a non-luminous flame. A reference to the accompanying sketch, Fig. 76, will serve to show that the flame thus produced consists of, first, a dark cone, which is cold unburnt coal gas mixed with 62 per cent. of air, and an outer flame mantle composed of burning coal gas mixed with air—a luminous point at the top of the inner zone only visible if the air-holes at the basement are partially closed.

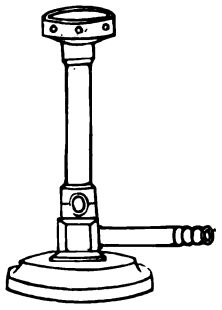


FIG. 75.—BUNSEN BURNER.

The flame of a Bunsen burner at a low temperature is suitable for observing the flame colorations of volatile substances.

At the highest temperature, a zone of fusion *c;* it is suitable for fusions at high temperatures.

The lower oxidizing flame *d* is suitable for oxidation of substances in borax or other beads.

The lower reducing flame *a* is serviceable for reductions on charcoal and for fusing borax or other beads in the reducing flame.

The upper oxidizing flame *e*, obtained by admitting the maximum of air, is suitable for oxidation at lower temperatures.

The upper reducing flame *b* is used for reductions, and possesses greater reducing power than the lower reducing flame already mentioned.

The principal advantages of the Bunsen burner are its small consumption of gas, the great heat it gives out, and entire freedom from smoke. They are made in many shapes and sizes.

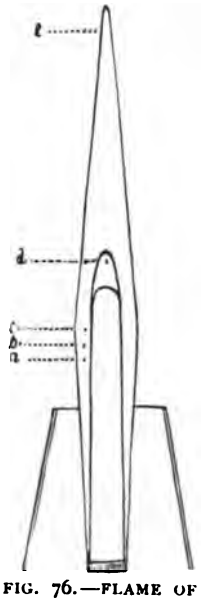


FIG. 76.—FLAME OF BUNSEN BURNER.

BURETTE.—A little instrument consisting of an attenuated tube fitted on to a stand, combined to contain exactly 1,000 grains of water and graduated into one hundred equal parts, so that for each division emptied ten grains have been expended (Fig. 77).

BURNISHER.—A machine for giving a high polish to photographs (see Fig. 78). Prints, after they are mounted on cardboard, and before they are perfectly dry, are given a finish by rolling or burnishing. In burnishing, the face of the mounted print is

lubricated with soap and passed over a steel burnishing bar heated by a lamp or gas jet. In passing over the heated steel bar, it is kept tightly pressed against it by a roller at the top, and by this means a polished or glossy surface is given to the print. If the print be enameled by any of the enamel processes, burnishing is unnecessary. There are various kinds of burnishers sold. Select one with a good piece of hardened polished steel, and with an arrangement for easily removing or getting at the same for cleaning. It should work evenly and smoothly. It is essential that the steel bar be kept perfectly clean and free from rust, as the slightest bit of foreign matter will mark every print passed over it. Should it get scratched it must be re-polished with fine emery powder mixed into a paste with paraffin oil, and lastly with a piece of dry chamois leather.

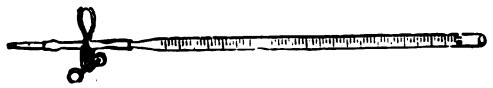


FIG. 77.—GEISSLER BURETTE.

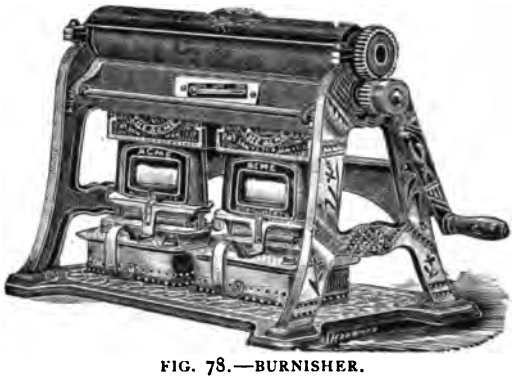


FIG. 78.—BURNISHER.

BURNISHING.—A method of giving a high gloss to prints. The mounted print is first lubricated by rubbing over the face a piece of flannel dipped in Castile soap solution, made by dissolving 3 grains of Castile soap in an ounce of alcohol. It is then passed through a heated burnisher (see **Burnisher**) several times, the pressure increased each time. No stoppage must occur in passing the prints through, or an ugly ineffaceable mark will be the result. The face of the albumen paper passing over the heated bar of polished steel soon takes a gloss. Burnished prints should be stood up to cool; if placed one upon the other, they lose their gloss.

BURNT-IN PHOTOGRAPHS.—See **Ceramic Photography.**

BURNT SIENNA.—A coloring matter used in backing plates to prevent halation. See **Backing.**

BURTON'S PROCESS.—See **Emulsions.**

BUST PORTRAIT.—A portrait which shows only the head and a portion of the bust of the sitter.

BUTTERFLY STOP.—The invention of Sutton, and employed by him in his panoramic camera to equalize the light. Two little wings of brass were secured on the stop in such a manner that whether held at right angles obliquely or viewed direct it always presented a circular aperture.

BUTTON-HOLE CAMERA.—See **Vest Camera.**

C. de V.—See **Carte de Visite.**

CABINET.—Abbreviated term for a cabinet picture.

CABINET MOUNT.—A mount for a cabinet photograph.

CABINET PICTURE.—This term was originally applied to small pictures or paintings from the old masters painted on panel, copper or canvas, and which, from their size and value, would be preserved in a cabinet. It is now generally applied to photographs of a size about $4\frac{1}{4} \times 6\frac{1}{2}$ inches

CADMIUM BROMIDE (Formula $Cd\,Br_2\,4H_2O$, Molecular weight, 344).—Prepared by heating cadmium to a red heat in bromine vapor. It takes the form of a white crystalline solid, non-hygroscopic, and sparingly soluble in water. It is used in the collodion process, and is preferable to the other bromides on account of its stability, solubility in alcohol or ether, and purity.

CADMIUM CHLORIDE (Symbol, $Cd\,Cl_2$).—Prepared by dissolving the metal or oxide in hydrochloric acid and evaporating.

CADMIUM IODIDE (Symbol, $Cd\,I_2$; molecular weight, 366).—Prepared by digesting one part of the metal cadmium with two parts of iodine in the presence of water. The solution is then evaporated, and yields large flat micaceous crystals of a pearly lustre. They are anhydrous and permanent in the air, and will only melt when heated to about 600 deg. Fahr., forming an amber-colored fluid.

Cadmium iodide is freely soluble in water, alcohol or ether. The solution reddens blue litmus paper.

It is used in photography as an iodizer for collodion. Collodion iodized with cadmium bromide, unless contaminated with zinc iodide, does not discolor if kept in a cool dark place. If zinc iodide is present the crystals are imperfectly formed, and when dissolved in ether or alcohol liberate iodine.

CADMIUM SALTS.—These may be distinguished by the fact that they give with sulphuretted hydrogen in faintly acid, neutral or alkaline solutions, a yellow precipitate, insoluble in caustic soda.

CALCINATION.—The operation of expelling from a substance by the application of heat, or by other means, the water or volatile matter combined with it. The operation of reducing a metal to an oxide.

CALCINE.—To reduce to a powder; to oxidize, or reduce a metal to an oxide.

CALCIUM (Symbol, Ca; atomic weight, 39.9).—A light yellow metal, malleable, oxidizes in damp air (becomes converted into hydrate), decomposes water, and dissolves easily in dilute acids. Calcium unites with all the non-metallic elements to form compounds.

Calcium is found as calcium carbonate in the forms of marble and limestone, in the bones of animals as calcium phosphate, and in various forms in many other substances.

CALCIUM BROMIDE (Symbol, $CaBr_2 4H_2O$; molecular weight, 272).—Prepared by burning calcium in bromide vapor, or by saturating hydrobromic acid with carbonate of lime. The solution thus formed is then evaporated, and yields silky hydrated needle-like crystals. These may be converted into the anhydrous salt by ignition. Calcium bromide is deliquescent and very soluble in water or alcohol.

CALCIUM CARBONATE.—See **Chalk.**

CALCIUM CHLORIDE (Symbol, $CaCl_2$; molecular weight, 111.)—Synonym, *muriate of lime.* This salt is found in sea-water, but is usually obtained as a by-product in the preparation of ammonia gas, or by dissolving chalk, marble or lime in hydrochloric acid and evaporating.

Calcium chloride is highly deliquescent. 100 parts of the powder will, if exposed to an atmosphere saturated with aqueous vapor, absorb 124 parts of water in 96 days. This property makes it very useful in many photographic operations for drying gases or depriving ether and alcohol of water. It is used for drying photographic preparations, and in the platinotype process for keeping the paper quite dry by absorbing all the moisture contained in the tube in which it and the paper are placed. See **Calcium Tube.** For these purposes a common quality will be serviceable, as pure dry calcium chloride is rather expensive. It is also used as a reducer for bromide prints.

Calcium chloride is very soluble in water and alcohol. It crystalizes in prisms, having the formula $CaCl_2 6H_2O$.

CALCIUM IODIDE (Formula, CaI_2; molecular weight unknown).—Prepared by saturating hydriodic acid with carbonate of lime, or by the action of iodine on calcium sulphide suspended in water. This salt is useful for the preparation of other iodines. It takes the form of a white deliquescent mass, soluble in water and alcohol. Sometimes employed in making collodion.

CALCIUM OXIDE (Formula, CaO. Synonyms, *Lime*, *Quicklime*).—Made by exposing chalk, marble or other variety of calcium carbonate, to a red heat. Slightly soluble in water, insoluble in alcohol. Plain lime water is employed as a test. A solution of it with sugar is used for rendering pyro alkaline. It is also employed for blackening negatives whitened with mercury. Cylinders of hard lime are used in the hydrogen lamp, the lime being heated by a flame of oxygen gas.

CALCIUM SALTS can be tested for with ammonium oxalate which gives a white precipitate, or with sulphuric acid, which gives the same in concentrated solutions.

CALCIUM SULPHATE.—See **Plaster of Paris.**

CALCIUM TUBE.—A cylinder of metal capped at each end. It is used for preserving platinotype or other ready-sensitized papers. In one of the caps is a perforated chamber containing asbestos, impregnated with calcium chloride, which has the property of absorbing the moisture contained in the air surrounding it. By this means the paper placed in the cylinder or tube is kept perfectly dry. When the asbestos becomes a damp mass, owing to the deliquescence of the calcium chlorine contained in it, it is placed on a metal plate over a fire, and the moisture driven off by heat. It can then be used again.

CALOMEL.—See **Mercurous Chloride.**

CALORESCENCE.—A molecular transformation of thermal into luminous ether waves.

CALORIFIC.—Having the property of producing heat.

CALORIFIC RAYS.—The heat rays of the spectrum. See **Spectrum.**

CALOTYPE.—A paper negative process patented by Fox Talbot in 1841, and also known as the Talbotype process in honor of the inventor.

The outlines of the process are as follows: A carefully-selected paper of fine and even texture is brushed over on one side with a solution of silver nitrate (16 grains to the ounce of water) and allowed to dry. It is then dipped in a solution of potassium iodide (500 grains to the pint of water), and allowed to remain for two or three minutes to allow the iodine to combine with the silver and form silver iodide. The paper is then rinsed in pure water and dried, when it will be seen to be covered with a pale yellow coating of silver iodide, which is practically unacted upon by light. When the paper is desired for use it is taken into the dark room and carefully brushed over with the gallo-nitrate of silver, made by mixing an aqueous solution (50 grains to the ounce) of nitrate of silver with one-sixth its volume of acetic acid, and adding an equal quantity of a saturated solution of gallic acid. This paper is then ready for use either wet, or it can be dried and used at a future period, and the image brought out by brushing more gallo-nitrate of silver over the surface. See also **Greenlaw's Process.**

CAMARSAC'S PROCESS.—The ceramic or burnt-in enamel process was formerly known under this name, M. Lafon Camarsac being the first to discover the possibility of transferring a positive image, formed of vibrifiable substances, to porcelain, and by submitting to a high temperature obtaining an enamel reproducing the original photograph.

CAMEO PHOTOGRAPHS.—Photographs to the surface of which a slight convexity is given by means of a die and press.

CAMEO PRESS.—A press for giving a convexity to the surface of photographs.

CAMEOTYPE.—A small vignette Daguerreotype suitable for mounting in a jewel case like a cameo.

CAMERA.—Essentially a dark box arranged to hold a convex lens at one end and the focusing screen at the other, the latter being replaced at will with an arrangement holding the sensitive plate or film so adjusted as to occupy the same place as the focussing glass. The earliest form of camera constructed by Daguerre was nothing more than this (see Fig. 79), but very many improvements have since been made, and various kinds of cameras constructed for different purposes. We will endeavor to explain them:

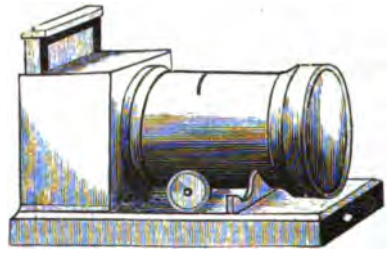


FIG. 79.—DAGUERRE'S CAMERA.

The Plain Camera is built entirely of wood. Focussing is accomplished by pushing, in or out, the back portion which slides into the front part. This is the commonest form of camera, and is suitable only for home work, as it possesses none of the necessary arrangements required for out-door work.

Bellows Camera. In this the back and front portions are connected by an expanding cover resembling the bellows of an accordion made either paralled square or conical (see Fig. 80). Cameras of this class are fitted with a screw, a rack and pinion focussing arrangement (by means of which a very exact adjustment can be made), a reversing back, a swing back and a rising and moving swing front. A description of these arrangements and their uses will be found in their respective places in this work.

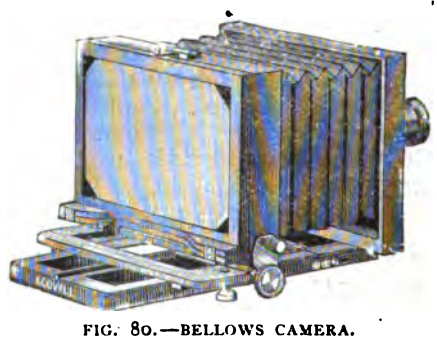


FIG. 80.—BELLOWS CAMERA.

The principal requirements in a camera are compactness and portability, although to secure this, rigidity must not be sacrificed, as nothing is more fatal to success than vibration of the camera during exposure.

Many of the modern cameras are fitted with detachable fronts to enable one lens to be quickly changed for another. Each lens being fitted to a different front it is easily fitted into its place and secured into a light-tight position by clamps or some similar arrangement.

Another modern improvement is the revolving front, which has for its object the bringing of the lens opposite any desired part of the screen, the revolving part being circular and the lens fitted at one side of the circle.

Double Extension, or *Long-focus Camera.*—To photographers who use a number of lenses of varying foci a double extension camera is a necessity. This camera is specially constructed to be used with a long focus lens, with which the screen must be placed some distance back to secure a sharp picture. A large number of different patents have been taken out for arrangements to secure this result, all being based upon nearly the same principle, which is that the base-board, to which the front and back of the camera are attached, is made double, one part fitting upon, or into, and sliding over the other, so that by this means the base-board, when fully extended by racking it out, is nearly double its usual length. In some cameras the

back or front have to be separated by racking out the whole length with the rack and pinion arrangement; in others the front is attached at once to a more distant point, and a few turns of the focusing suffice to secure a sharply-defined image. Extension cameras of this kind may also be divided into two sub-classes, *i.e.*, "back extensions" and "front extensions." With the former the back portion of camera is attached to the extending part of the base-board, and in the latter the reverse. In the opinion of the author the front extension arrangement is the best, as with the other form the double dark slide, containing two heavy plates, is racked out, and will be likely to vibrate from very slight causes. In front extension cameras, however, one is liable when working with a very wide-angle lens to find part of the base-board obstructing a portion of the view, but this defect is removed in some cameras by an arrangement by which when working with this kind of lens the back may be detached from its position and placed close up to the the front. In purchasing cameras of this kind it is essential to observe that the base-board is firm and rigid, even when racked out to its fullest length. It should also close up so that a short focus wide-angle lens can be used.

FIG. 81.—DOUBLE EXTENSION CAMERA.

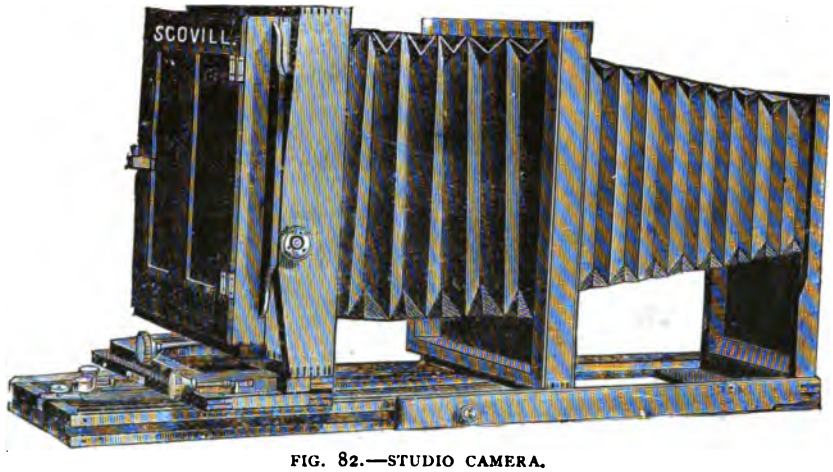


FIG. 82.—STUDIO CAMERA.

The sizes of cameras usually made are for plates of the following dimensions in inches: 3¼ x 4¼; 4¼ x 5½; 4¾ x 6½; 5 x 7; 5 x 8; 6½ x 8½; 8 x 10; 10 x 12; 11 x 14; 12 x 15; 14 x 17; 16 x 20; 17 x 20; 18 x 22: 20 x 24; 22 x 27; 25 x 30; 30 x 38. The last three sizes are for studio work.

Studio Camera.—This is a camera specially built for use in the studio. In this many of the arrangements and fittings attached to the tourist or portable camera will be found, though the whole is built in a more solid manner, as it is only necessary to study rigidity and firmness without portability. A good studio camera should have a swing-back, a rising and sliding front, and other arrangements for portrait work.

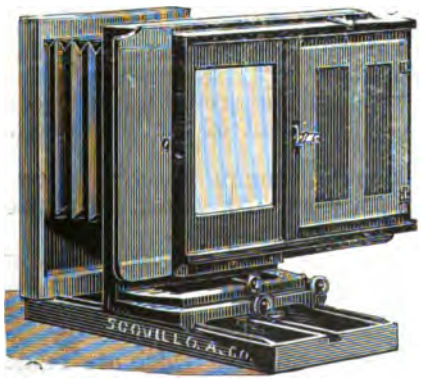


FIG. 83.—STUDIO CAMERA WITH SLIDING PLATEHOLDER.

Fig. 82 represents a perfect form of studio camera for portrait work and other purposes, as it can be racked out to a great extent.

FIG. 84.—DETECTIVE CAMERA.

Fig. 83 is another form of studio camera. It has a carriage for the plate-holder so that when the operator brings the plate-holder from the dark-room he slides it into the carriage. He then focuses again in case the sitter has moved, slides the ground glass to one side and simultaneously brings the plate-holder into place.

Hand Camera.—A form of camera that can be conveniently operated when held in the hand. Fig. 85 is an illustration of one. The front portion holding the lens and finder slides into the back part, and the box can be closed up.

FIG. 85.—HAND CAMERA.

Multiplying Camera.—A camera usually employed in making ferrotypes. It contains a number of small lenses partitioned off and giving several images upon the plate at one time (Fig. 86). See also **Stamp Photographs.**

Vertical Camera.—For photographing many objects such as specimens, flowers, etc., which can be better arranged on a horizontal plane a camera fitted up in a vertical position is to be preferred. A convenient arrangement is that devised by M. Donnadieu shown in Fig. 87.

The base, A, of hard wood or metal, is 24 inches square in front, and is cut away to form a prolongation 20 inches long, to which is fastened the brace, G. Other braces, G G, are fastened to the corner of the square portion of A, as shown. These braces are provided with tightening screws, F, F, F. The base supports a vertical column, B, made of a piece of brass tubing 2 inches in diameter, and 6 to 8 feet long. A rack is soldered the whole length of this column, to receive the cogs of the wheels, D, D, D, by means of which the various adjustments are effected. The top of the column is fastened to brass plate, K, by means of a screw. The upper ends of the braces are fastened to the end of the plate, K. These braces may be made of the small wire rigging used on shipboard, or they may be made of small brass rods or stout wire. The column, B, is provided with cast brass sockets, carrying the adjustment wheels, D, D, D, and metal frames. The frame at C is intended to hold a microscope or an object mounted on glass. The frames at C′ and C″ support respectively the front and the back of the camera, which are 10 inches square. They are connected by a bellows which has a length of draw equal to the height of the column, B. The image is received through the open doors, replacing the usual ground-glass screen by one of plain glass, on the inner surface of which a sheet of plain white paper is pasted. If the apparatus is low enough to allow the image to be seen in the usual way the ground-glass screen may be used. It is well to place two small castors underneath the front of the base and a levelling screw at the back.

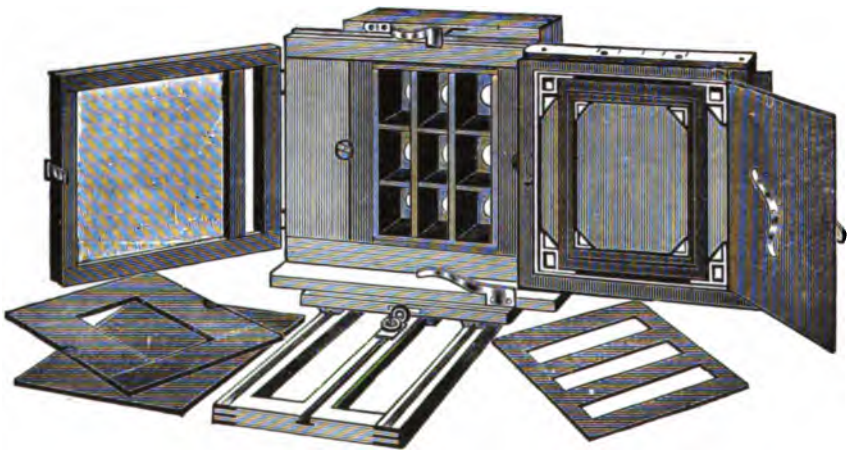


FIG. 86—MULTIPLYING GEM CAMERA.

Stereoscopic Camera (Synonym, *binocular camera.*)—A double camera fitted with two lenses, their centres distant about two and a half to three inches, and their foci equal. The size of the plate receiving the images formed by the two lenses is usually $6\frac{3}{4}$ x $3\frac{1}{4}$ inches.

Another method of making stereoscopic views is by using one camera on a sliding arrangement, with which the camera could be shifted the required distance after making the first picture. With this arrangement, however, it is impossible to include moving objects in the pictures taken. See **Stereoscopic Photography.**

Detective Camera.—Under this heading we may include all those cameras which are made to look as least like a camera as possible, (Fig. 84—illustrates an ordinary form), or which are capable of taking pictures when hidden from sight. A large quantity of these have been

manufactured in almost every conceivable form. Among the many we may mention the watch camera, made in the form of a watch; the hat camera, fitted in the hat; the opera glass camera, made in the form of a pair of opera glasses; the vest camera, made to be worn behind the vest; the parcel detective camera, disguised in the form of a box wrapped in brown paper, and tied with string like an ordinary parcel; and others of larger size made to appear in the form of a satchel or leather-covered case. See **Vest Camera, Book Camera, Watch Camera,** etc.

Enlarging and Copying Camera.—A camera constructed for copying or enlarging negatives or positives on glass or paper. See **Enlarging** and **Copying.**

Solar Camera.—This apparatus consists of an arrangement for enlarging in which the solar rays of the sun are used for the light to illuminate the negative. There are two methods—one is to illuminate the negative by the direct solar rays, and the other is an arrangement by which these rays are first concentrated by a lens. Fig. 88 will serve to explain the construction of the latter form of apparatus. Here B is the condenser, N is the negative, O is the objective, a photographic lens adjustable by the pinion H, and R is the board for pinning the sensitive paper to, adjustable by the pinion to the condenser C. The mirror M throws the rays of the sun *r r r* on to the condenser, and the negative N to be enlarged is placed between the lens and the condenser at a distance varying with the size of the enlarged image required.

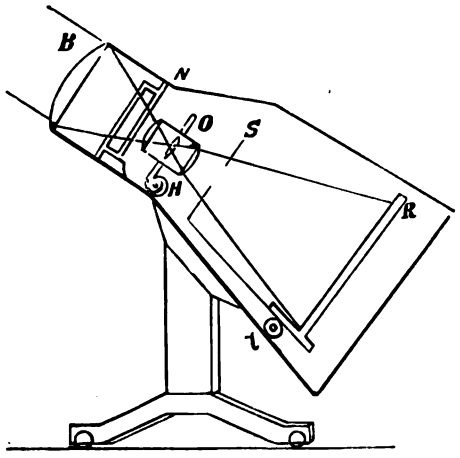


FIG. 88.—SOLAR CAMERA.

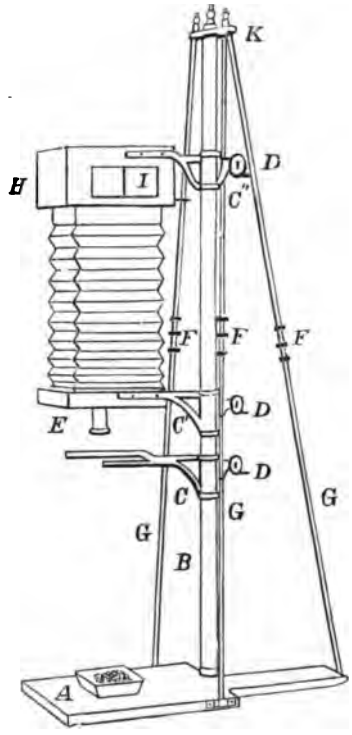


FIG. 87.

It is only necessary to place this apparatus in a darkened window and adjust the mirror keeping the solar rays always reflected in the same direction. This apparatus is but little used now. The more modern arrangements for enlarging will be found under that heading.

Photo-micrographic Camera.—A camera for photographing microscopic objects. The simplest form consists of a long mahogany camera, containing dark slide and focusing screen, and which can be fitted on to the tube of a microscope. See **Photo Micrography.**

Panoramic Camera.—A camera used for making panoramic views or groups. See **Panoramic Photography.**

CAMERA BAG or **CASE.**—A bag or case to contain the camera and its fittings for convenience in traveling. These are made of all kinds of material, from the common canvas to the finest leather. A good waterproof canvas answers the purpose well. It should be fitted with lock and key to prevent inquisitive persons examining its contents or meddling with the plate-holders. The best camera cases are made of good stout leather, and lined inside with velvet to prevent the scratching of the polished wood of the camera.

FIG. 89.—CAMERA CARRIER.

CAMERA CARRIER.—An arrangement for carrying the camera when touring. A carrier for attachment to a bicycle is shown in Fig. 89.

CAMERA LUCIDA.—An arrangement designed to facilitate the delineation of objects. It consists of a rectangular glass prism A B C (Fig. 90), having one of its sides turned to the object to be depicted, while the other is at right angles to the inclosed plane of glass D E.

The ray *r* proceeding from the object O enters the prism at F, where it is slightly refracted, It is totally reflected at G, again refracted at H, and partially reflected at I, reaching the eye at J, so that the image is seen apparently at O, whilst the point of a pencil is clearly seen at the same place, enabling one to trace distinctly the image of the object O^1.

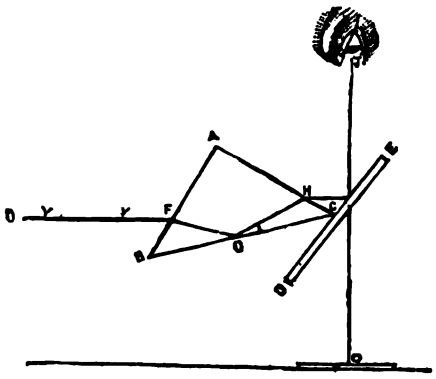


FIG. 90.—CAMERA LUCIDA.

CAMERA OBSCURA.—An instrument in which, as its nam eimplies, the essential feature is a dark chamber. It is said to have been invented by John Baptista Porta, a Neapolitan philosopher. But although a description of the instrument is given in his "Seventeenth Book of Natural Magick, wherein are propounded burning glasses and the wonderful sights to be seen by them," published in 1658, yet it is generally believed that the invention dates much farther back, and was known to Friar Bacon in the thirteenth century. It we take a room and exclude all light except that which enters at a small hole made in the window-shutter, we shall obtain, when the sun is shining, an inverted image of the objects outside thrown upon the wall opposite the aperture. The delineation is, however, very imperfect, but by placing a double convex lens in the aperture and a sheet of white paper in its focus, we obtain a perfectly sharp image. By making a miniature room out of a box formed of two parts sliding into each other to adjust the focus for objects more or less distinct, we have a modern camera obscura (Fig. 91). A lens is fitted into one side, and the rays entering it fall on the mirror arranged at an angle of 45 deg., which will reflect them upwards and reverse the image, which would otherwise appear upside down at the end opposite to the lens. The image is reflected on to a piece of ground glass or a piece of plain glass and a sheet of white paper laid over it, enabling one to trace the outlines of the picture.

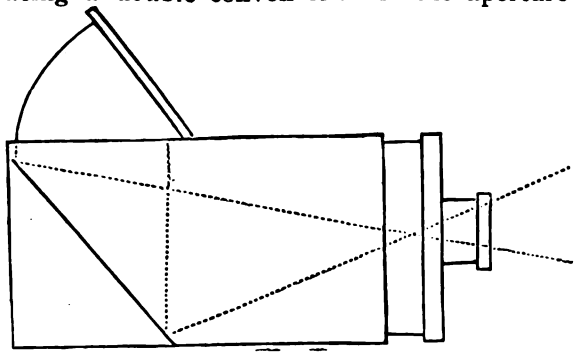


FIG 91.—CAMERA OBSCURA.

Another form of camera obscura is that often seen at fairs. In this a triangular prism, acting as a condensing lens and mirror combined, throws down upon a white table a representation of the surrounding scenery.

CAMERA STAND.—A table arrangement to hold the camera. The studio camera stand should be solidly built, and have the new arrangements for raising, lowering and tilting the camera (see Figs. 92–93). For all other classes of work the camera stand having for stability three legs is termed a tripod, *q. v.*

FIG. 92—.STUDIO CAMERA STAND.

CAMPHOR (Formula, $C_{10}H_{16}O$; molecular weight, 152; synonym, *laurel camphor*).—Obtained by dissolving with water the leaves and wood of the camphor tree (*Laurus camphora*), a native of Japan, Formosa and central China. It is a solid white volatile crystalline mass, very tough, and difficult to pulverise. It possesses a peculiar odor, and is soluble in alcohol, ether, and strong acetic acid, but almost insoluble in water; 1 part will dissolve in 1000 of water. It is sometimes added to gelatine, albumen, etc., to prevent decomposition and mould. It is also used in the manufacture of celluloid. A small piece of camphor added to the kerosene oil in a lamp increases the whiteness of the flame.

CANADA BALSAM.—A pale yellow oleo-resin obtained by incision from the American silver fir, a Canadian tree. It is soluble in benzole, and a solution thus prepared will render paper highly translucent. Its principal uses in photography are in cementing the various components of lenses together (see **Cementing Lenses**), and in mounting microscopic objects to be photographed. It is also employed in the manufacture of certain varnishes.

CANARY MEDIUM.—A yellow-colored cloth used for dark-room illumination. Light filtered through it has but little action upon sensitive material unless prolonged. See **Dark-room.**

CANDLE BALANCE.—An instrument used in photometry to determine the weight lost by a candle burning a given length of time.

CANDLE POWER.—The illuminating power of a sperm candle burning at the rate of 120 grains per hour.

CANVAS PRINTING.—See **Printing.**

CANVAS, MOUNTING ON.—Albumen, or other prints can be mounted on canvas. First soak the canvas in a gelatine or glue solution, then sketch upon a wooden frame. When dry and perfectly tight, the prints can be readily mounted with starch paste. This is a convenient method when large prints are to be carried about. They can be handled carelessly without fear of being torn.

CAOUTCHOUC.—An American-Indian word for the substance known also as indiarubber. A solution of caoutchouc is sometimes employed for mounting gelatino-chloride prints so as to preserve the gloss. It is not an advisable method as the rubber after a time becomes hard, crumbles, and the print leaves the mount either wholly or in part. It is also used in the Woodburytype process. The best india-rubber solution is made by cutting a block of rubber in two, extracting the centre portions and dissolving them in anhydrous benzole. It is also employed as a substratum in certain processes.

FIG. 93.—STUDIO CAMERA STAND.

CAP.—The leathern covering fitting on to the end of the lens, which protects it from dust and shuts out the light when required. If an instantaneous shutter is not used, the exposure is usually made by removing and replacing the cap. It is therefore necessary that the cap should fit easily on to the hood of the lens. If too tight, it is possible that, in removing, the camera may be caused to vibrate, while, on the other hand, if too loose, it is likely to fall off, or to allow stray rays of light to enter the camera and produce fog on the sensitive plate. It should be lined inside with black velvet, and it is a good plan to attach it to the camera with a piece of string to prevent its being lost. For the better preservation of lenses it is well to have a cap to fit both ends. A cap fronted with yellow glass is very useful when enlarging with a lens. It enables the operator to readily adjust the sensitive paper to the image without fear of fogging.

CARAGHEEN MOSS.—An Irish moss or species of sea-weed (*Spæroccus erispus*) from which a jelly is manufactured. It has been used in photography in place of gelatine for suspending the silver salts to form an emulsion.

CARAMEL.—A black soluble compound obtained by heating sugar or molasses to about 200 deg. C. It is often recommended in formulae for backing plates to prevent halation.

CARBAZOLIC ACID.—See **Picric Acid.**

CARBOLIC ACID (Formula, C_6H_5HO; synonyms, *phenol, phenyl-hydrate, phenic acid.*)—Almost exclusively manufactured from the coal tar produced in gas manufacture. Pure carbolic acid forms colorless needles, of a distinct odor, which melt at 95 deg. F. into an oily liquid having a strong odor and taste. Carbolic acid is freely soluble in alcohol, ether and glycerine, and but slightly in water. Unlike other acids, it does not redden blue litmus paper. It is a powerful antiseptic, and is largely used as a disinfectant. A minute quantity, if added to albumen or gelatine, will prevent mould and decomposition. For the former, the quantity must be very small, as carbolic acid coagulates albumen.

CARBON (Symbol, C; atomic weight, 12).—Carbon occurs in three allotropic forms—diamond, graphite and charcoal. Carbon for photographic purposes is usually prepared from lamp black. This black being very stable—that is to say, retains its color for such a long period, as evidenced by the ancient manuscripts—it is clear that photographs made in such a manner that the coloring matter is practically pure carbon will be very permanent. Upon this principle the carbon process and Woodburytype are based.

CARBONATE OF AMMONIA.—See **Ammonium Carbonate.**

CARBONATE OF POTASH.—See **Potassium Carbonate.**

CARBONATE OF SILVER.—See **Silver Carbonate.**

CARBONATE OF SODA.—See **Sodium Carbonate.**

CARBONATES.—All carbonates effervesce when treated with hydrochloric acid. Soluble carbonates give a white precipitate soluble in nitric acid, with nitrate of silver.

CARBON DIOXIDE (Formula, CO_2).—More familiarly known as *carbonic acid.* The name carbonic acid is, however, the one with which all are familiar. Other synonymous terms are *carbonic* anhydride and *carbonic oxide* (by a few chemists). It is a colorless gas about 1½ times as heavy as air. It is evolved in large quantities in active and extinct volcanoes; it accumulates at the bottom of deep pits and wells. It has an agreeable odor, but if respired it produces insensibility and death. At a pressure of 38.5 atmospheres at 6 deg. it is converted into a colorless liquid, insoluble in water, but soluble in alcohol or ether.

CARBON DISULPHIDE (Formula, CS_2; synyonyms, *sulphocarbonic acid, sulphuret of carbon*).—Made by passing sulphur vapor over red-hot charcoal. It is a colorless, volatile and inflammable liquid. It is employed in the manufacture of some cold varnishes, as it dissolves amber and other resins. Great care must be taken in using it, as both the liquid and the vapor given off are inflammable and highly poisonous. Further, a mixture of the vapor and air forms a highly explosive compound.

CARBON PROCESS (Synonym, *autotype*).—A process based upon the fact that gelatine and other organic substances, if heated with a bichromate, become sensitive to light which renders them insoluble in the parts exposed. This fact was discovered by Mungo Ponton in 1838, but it is to the subsequent discoveries and improvements of Becquerel, Poitevin, Pouncey, Swan and Sawyer that we are indebted for the simple and efficient carbon or autotype process of the present day.

The carbon tissue prepared for this process consists of paper coated with gelatine containing carbon, lampblack or other pigments (see **Carbon Tissue**).

It can be purchased readily sensitized, but in this condition will not keep for any length of time.

Cutting up the Tissue is performed by unrolling it gently upon a zinc cutting plate, cut square and true, with the inches marked at the bottom and right hand side. By using a T square and observing the numbered inches marked on the plate, it will not be difficult to cut the tissue to any dimensions. If the tissue is very curly and unmanageable it should be kept down with convenient weights. After cutting it up to the required sizes, which should be conveniently smaller than the dish to be use for sensitising, it should be kept flat under a metal plate.

Sensitising the Tissue is the next operation. This is performed in a solution of potassium dichromate rendered alkaline with ammonia. Tie over the mouth of a two-gallon jug a piece of muslin, to form a kind of bag, into which place fifteen ounces of potassium dichromate, then fill up the jug with water and allow it to stand till the dichromate is dissolved and the solution become cold. It is sometimes advisable to regulate the quantity of dichromate. In hot weather, or for very thin negatives, the proportion of water should be doubled, while for very hard negatives only half the quantity should be used. In very hot weather it is a good plan to replace about 30 per cent. of the water with the same quantity of alcohol.

The operation of sensitising the tissue must be carried on in a room lighted by a window covered with a yellow blind. A flat dish of porcelain, glass, or *papier maché*, a squeegee, and a sheet of glass or zinc a size larger than the tissue, will be required.

The solution is poured into the dish, and should be at least two inches deep; the tissue is then immersed in it, and the air-bells that form immediately brush away from both sides with a broad camel-hair brush. The temperature of the bath should not be higher than 60 deg F., and the time of immersion should be from three to five minutes. After the tissue has remained in the solution for the allotted time it is gently removed and laid face downwards upon the glass or zinc plate, and the back squeegeed, removing all snperfluous solution. The tissue is removed from the glass and laid over a sheet of cardboard, bent into the form of an arch, to dry.

Another method (H. J. Burton's) of sensitising carbon tissue is to lay it flat on a sheet of clean blotting paper, and sponge on the back a very strong sensitising solution composed as follows:

Potassium dichromate	4 ounces
Liq. ammonia fort	1 "
Water	20 "

First mix the ammonia with the water, then grind up and add the dichromate.

Drying the Tissue should be accomplished in a room perfectly free from the noxious fumes of other chemicals, and lighted only by non-actinic light. Tissue sensitized during the evening should be dry on the following morning. It should then be cut to the sizes required and kept flat in a pressure frame or other similar contrivance.

Exposing the Tissue.—The tissue can be exposed behind the negative in an ordinary printing frame, or in special frames having no joint in the back, as no image is visible. The negative must be furnished with a safe edge, made by painting an edge about one-eighth of an inch round the negative with black varnish, or by pasting on strips of red or black paper. Exposure must be judged by an actinometer. Several forms of this instrument are described under the heading **Actinometer.** A very suitable instrument for toning the exposure of carbon tissue is Sawyer's actinometer. It consists of a rectangular tin box with a glass lid, bearing twelve tints gradated from slight discoloration to a degree of opacity, representing the extreme

amount of deposit upon the lights of the densest negatives, each division of this screen of tints bearing a number in opaque pigments; a roll of sensitive paper is placed in the box, and the end pulled forward so as to pass under the tints. When this arrangement is placed in the light, the silver paper commences to discolor underneath the gradated screen, beginning of course at the lightest division, but the number on the tint being in an opaque pigment is preserved white, and serves to register the progress of printing; for if, when the lid is opened, the number one, for instance, shows clearly on a tinted ground, the instrument is said to have registered one tint; by that time the number two will have begun to make its appearance, and if sufficient exposure be given the light will print through the whole scale by successive steps, and show up the numbers one to twelve. With an instrument of this kind it is evident that, by exposing at the same time as the carbon tissue and determining the number of tints required for the proper exposure of that negative, the same number of tints with the same negative will always prove correct. A little practice will enable one to judge the number of tints required for every class of negative.

It will be well to remark here that freshly sensitized tissue will produce inferior pictures to that used a day or two after; the pictures are not so hard, and there is less danger of the high lights being washed away.

Continuing Action of Light.—If the carbon tissue, after exposure to the light, be kept in the dark for a little time the effect on the print will be precisely the same as if the exposure to light had been prolonged. This continuing action may often be utilized to advantage. Pictures known to be under-exposed will, if kept till the morning, by that time have acquired the same force as if they had received the proper exposure. The action is accelerated by moisture; if kept in a very dry state in a drying cupboard it is arrested.

Development consists in simply dissolving the gelatine unaffected by light, with hot water as the solvent. Now, it will be seen that as the tissue is laid against the negative the parts acted upon by the light and rendered insoluble are on the surface of the gelatine film, the lower stratum next the paper remaining soluble. By placing the whole in warm water we should dissolve the lower portion of the gelatine film, detach the paper, and leave the insoluble picture floating about helplessly in the water, where it would soon be destroyed. To prevent this we attach the tissue to a rigid or flexible support to retain it intact whilst the process of development is being carried on, for if the pigment film after exposure be placed in water for a short time and then laid upon any plain surface impermeable to water it will firmly adhere to it, provided precautions have been taken to carefully exclude the air from between the surfaces. It will also adhere to paper prepared with an insoluble gelatine film or any other colloid body, provided the two surfaces are brought into contact in a moist condition.

FIG. 94.—DEVELOPING THE CARBON PRINT.

In transferring the pigment picture to a support, we obtain a reversed positive. For portraiture, seascapes, and many landscapes, this is often of but little disadvantage, and the picture may be developed by what is termed single transfer. For subjects which would be spoilt if reversed, what is known as the double transfer must be resorted to, unless in the first instance the negative was reversed.

Single Transfer.—Immerse the exposed tissue in a bath containing cold water. It will first of all curl up, but afterwards lie flat and limp. It is then placed in another bath containing cold water and a piece of single transfer paper (paper coated with a thin and insoluble gelatine) which has been soaked in water for a little while. Bring them together face to face, draw them out, and lay them upon a board, and force into close contact with a large squeegee; then place between blotting paper for five or ten minutes. In squeegeeing, the tissue should be uppermost, and a sheet of waterproof cloth laid over it to prevent the squeegee from damaging it.

Development should not be attempted for at least twenty minutes, during which time the tissue should be placed between sheets of blotting paper, and kept under pressure to ensure its adherence to the paper support. After that time it is placed in a dish, and water heated to a temperature of 100 deg. F. added. The colored pigment will at once commence to ooze out of

the edges, and after a little time the paper originally holding the carbon film may be removed with the hand. Then, by gently laving the picture with the hand, the superfluous gelatine will be washed away, and if the exposure has been correct a perfect image should remain. A certain amount of control can be kept over a carbon picture. An over-exposed print will show itself by insolubility of the gelatine, the high light refusing to be washed clear. The temperature should be raised considerably, and hot water poured over with a jug (Fig. 94). If this fails to reduce the intensity, add a little ammonia to the water as a last resource, although the better plan is to make another print, giving less exposure. Under-exposure results in over-solubility of the gelatine. The half-tones will be washed clean away. It is rarely an under-exposed print can be saved. All that can be done is to reduce the temperature of the water. Development should never be hurried; the slower it is the better the gradation of tone in the results.

After development is completed the bichromate salt is discharged and the image rendered perfectly insoluble by well washing in cold water and placing in a dish containing a 5 per cent. solution of potash alum, after which it is again washed and dried.

Double Transfer Process.—In this the development is the same, and the whole process similar, except that the tissue is squeegeed first on to a temporary support, and from this transferred to its permanent support. By this means we get a non-reversed print from an ordinary negative.

For the temporary support we may use paper,* zinc, or glass, and treat with a waxy solution of

Yellow resin	6 drams
Beeswax	3 ounces
Turpentine†	20 ounces

This solution is rubbed on with a piece of flannel and then polished with another clean piece of soft flannel. The carbon tissue is squeegeed on to this support in the same manner as described in the single transfer process, and after it has been developed, washed, fixed in alum, washed again, and dried, it is ready for transferring to the permanent support. The transfer may take place at once whilst wet, or the pictures may be hung up to dry and transferred at some future time.

The double transfer paper or permanent support is a paper coated with gelatine and barium sulphate. A piece of this paper cut to the right size is steeped in

Potash alum	1 ounce
Water	1 pint

some time previous to the first operation. This is then squeegeed in the usual manner to the developed print. It is then allowed to dry, and a knife point inserted under one corner will cause the temporary support to separate from the other, leaving the image firmly imbedded in the gelatinous insoluble *couche* of the permanent support.

The temporary support may be employed again by re-waxing in the manner described.

The pictures may be given a brilliant finish by applying a few drops of methylated spirit to the surface, rubbed over with a piece of flannel. Another method is to squeegee on to glass. This method will be found described in finishing bromide prints, and can be adopted with any picture in which the film or image is a gelatinous one.

Among the defects that will arise in carbon printing, it will be well to mention a few of the more important. If the tissue becomes insoluble, it is due to its having been dried in warm, damp air. It may also be caused by the following: Acid sensitizing bath, too long keeping after sensitizing, and exposure to light, gas fumes or dampness. Frilling is caused by a neglect of the safe edge, placing the film on the temporary support too soon after the waxing of the latter, or insufficient pressure after development. Spots are due to air bubbles, or dust between the tissue and the support. If the prints refuse to leave the temporary support, it is owing to imperfect waxing.

The carbon or autotype process is also largely used for making lantern slides, opal pictures, and transparencies. See under these headings. See also **Artiques Process** and **Papier Velours.**

Several methods have been devised for printing upon carbon tissue without the necessity of a transfer. A transparent or translucent material, such as tracing paper, celluloid film, etc., was coated over with the gelatine, containing the pigment, and exposure made through the paper or film. Valentine Blanchard recently described a similar method.‡

The system is this. The sensitive tissue is immersed in a petroleum oil until the paper is saturated, the gelatinous coating being unaffected by the oil. After the superfluous oil has been removed, the tissue is exposed behind the negative, with its paper side next it. The exposure is necessarily long—three times that required when the tissue is exposed in the usual way—because the light has to pass through the paper, and that is stained by the bichromate to a non-

* A special transfer paper, consisting of a smooth, tough paper, coated with shellac and rolled is sold commercially.
† E. J. Wall recommends ether in place of turpentine. The support can then be used immediately.
‡ British Journal of Photography.

actinic color. With this method much of the fine detail is lost, and the texture of the paper will be visible. It can only be employed for broad, artistic effects. A reversed negative is also necessary.

CARBON ENLARGEMENT.—An enlargement made by the carbon process. See **Enlarging.**

CARBONIC ACID.—See **Carbon Dioxide.**

CARBON TISSUE.—Paper coated with gelatine containing one or more pigments, and used in the carbon process, *q.v.*

The composition of the pigments used should be carefully studied. If carbon lampblack only is used, we get pictures that will last a long time, as proved by the brilliancy of printers' ink many years old. But it is nearly always necessary to add some other color to give an agreeable tone. The colors of the pigments used depend, of course, upon the kind of picture to be reproduced. For instance, if it is intended to reproduce a red-chalk drawing, by incorporating with the gelatine a pigment of the same color, an almost perfect *facsimile* may be obtained. To manufacture carbon tissue requires too much labor to be profitable to any but very large consumers. The Autotype Company manufacture their tissue, and sell the same plain or sensitized. This tissue may be obtained to give pictures of the following tints:—Standard brown, engraving black, sepia, red chalk, standard purple, warm black, portrait brown, portrait purple, special purple, sea green, and a special for transparencies.

A good carbon paper may be made as follows:

Gelatine	5 ounces
Isinglass	½ onnce
Water	70 ounces
Lampblack	¾ ounce
English red (peroxide of iron)	1 ounce
Glycerine	1½ ounces

Dr. Gunther gives this formula, and describes the method of preparing it as follows:—The gelatine should be neither too soft nor too cold, and the quantity of glycerine should be about equal to the volume of the coloring matter added. The black color is rubbed down on a stone slab, then the glycerine is added and the rubbing continued. Sufficient water is then poured on to obtain the required consistency, and the desired degree of fineness having been certain, the color is collected with a horn spatula. The red color is rubbed down with water only. The two colors are then mixed together on the slab. During the time occupied in preparing the colors, the isinglass, cut into small pieces, is allowed to soak in about 4 ounces of water. It is then boiled, stirring all the time, until but fine skins are floating in the somewhat muddy solution, when the whole is strained through linen. This solution is then poured into the gelatine, previously dissolved in lukewarm water. The coloring matter is now placed in a large porcelain dish, and the warm gelatine and isinglass solution added in small quantities, stirring all the time with a pestle until an even homogeneous mixture has been produced. The whole is at once strained through muslin or moistened flannel, and the mixture is ready for coating. For methods of coating paper with gelatine see **Coating.**

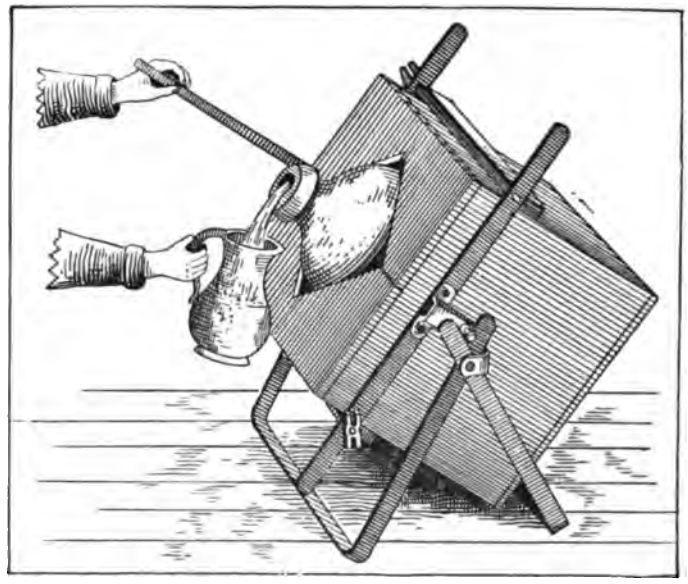


FIG. 95.—CARBOY STAND.

The plain paper should be tough and have a smooth surface. It must not be too strongly sized, as it requires to be readily permeated by the water when developing.* A gelatine should be used that is neither too hard nor too soft. As a rule, a mixture of the two kinds is employed.† In choosing the coloring matter only those that are permanent should be used. Liesegang gives the following:‡

* The Autotype Company now manufactures a carbon tissue prepared with a red paper support. After sensitizing, the paper is squeegeed to a ferrotype plate, and as the backing is of a non-actinic color the paper can be dried in the daylight.

† Sugar and soap are often added to prevent the film from becoming too brittle in very dry weather.

‡ A Manual of the Carbon Process. By Dr. Paul E. Liesegang.

Brown tones are obtained with caramel, dark oxide of iron, Indian red and carmine lake.
Purple tones with artificial alizarine and purpurine dissolved in caustic soda.
Warm black tones with mixtures of indigo, umber and carmine lake.

Dark-brown tones, with a mixture of Vandyke brown, two grains; Venetian red, three grains; indigo, one grain; carmine lake, one grain; bone black, fifteen grains.

Red-brown, with a mixture of China ink, three grains; carmine lake, four grains; Vandyke brown, four grains.

Photographic tones, with Indian ink, four grains; carmine lake, three grains, and Indian red, five grains.

For old engraving reproductions, sepia by itself, or mixed with a little bone black, can be employed.

Liesegang gives the following as suitable proportions for the gelatine mixture:

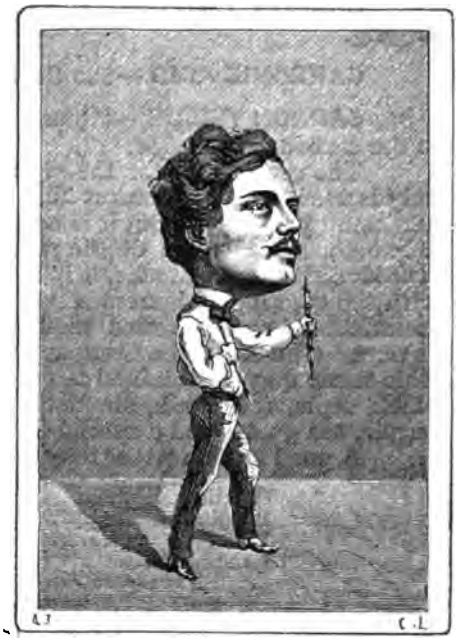
Water	1 onuce
Gelatine	120 to 150 grains
Soap	15 grains
Sugar	21 grains
Dry coloring matter	4 to 8 grains

CARBOY.—A large glass bottle enclosed in a box or basket. It is used for holding solutions, particularly corrosive acids.

CARBOY STAND.—An arrangement for holding a carboy, to facilitate the pouring out of the liquid. (Fig. 95.)

CARCEL LAMP.—A standard lamp used in photometry. It is equal to 9½ candles.

CARICATURE PHOTOGRAPH.—A photograph in which the natural characteristics of a person or object are exaggerated or distorted.



From Tissandier's Handbook.
FIG. 96.—CARICATURE PORTRAIT.

There are quite a number of different methods of making caricature portraits. A simple one is to make two photographs of an individual. One of the head alone and another of the entire body on a much smaller scale. From these two negatives prints are made, the larger head is cut out and pasted on to the shoulders of the full length figure. Any signs of the cutting out are removed by the use of a brush and a little coloring matter. From this combined print another negative is made so that any number of these caricature prints can be made without extra trouble. The effect is shown in Fig. 96.

Foregrounds for making caricature portraits are sold in this country. The method of using them is shown in Fig. 98. The card containing the grotesque drawing is held by the sitter on his knees and arranged by the photographer in such a way that his head rests just above the above the neck of the painted body. A white background is arranged behind and when the negative is made all traces of the edges of the foreground are removed by careful retouching.

FIG. 97.—CARICATURE.

Another method of obtaining grotesque caricature portraits has been devised by M. Ducos du Hauron. His apparatus, which he calls "La Photographie Transformiste," is thus described by Schnauss in his "Photographic Pastimes." A (Fig. 99) is the front of the box which is furnished with an exposed shutter formed of a simple sliding piece fitting into the grooves R R, R R. B B″ are two screens pierced with slits *a a*, *c c*. C is the rear end of the box where the dark slide is placed. D is the lid of the box, which is lifted either for placing the slotted screens or for putting in the sensitive plate. When not working direct from nature, the transparency is placed in the grooves at R R, R R, at A.

According to the arrangement of the slit, the caricatures obtained will be different. If, for instance, the first slit be a vertical one, and the other, *i. e.*, the one nearest the picture, a horizontal one, the picture, in comparison with the original, will be distorted lengthwise. If, however, one of the slits forms no straight line, but a curved one, the transformed picture will show either lengthwise or sideways curved lines, according to the slit being a vertical or a horizontal one. The form of the resulting picture will also be different according to which one of the slotted plates is inserted more or less obtusely in the box.

The slits must be made very exactly; above all, their edges must be absolutely sharp, every incorrectness being transferred to the picture. They may be made about one-third of a milimetre wide; if they are too narrow the picture will not turn out sharp. In making the slits it is a good plan to cut them in thin black paper, and to mount the latter on glass plates.

In a later description of the apparatus we learn that the discs containing the slits are now made circular in shape, and are so arranged that they can be revolved, as shown in Fig. 102. This, of course, allows of a still greater variety of positions of the two apertures in relation to each other and an increasing number of grotesque effects. Reproductions of some of the pictures obtained are given.

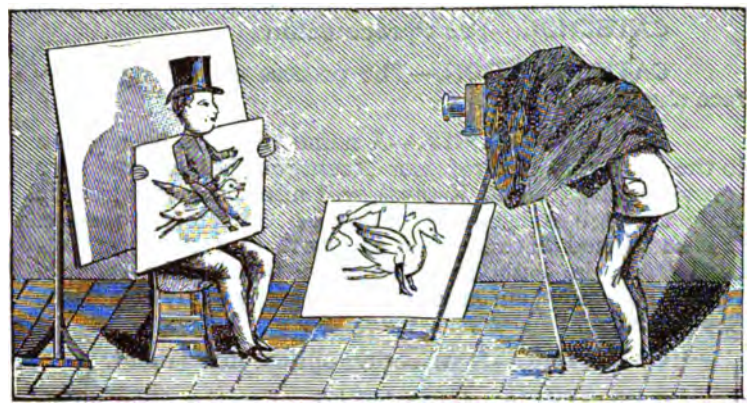


FIG. 98.—MAKING THE CARICATURE PORTRAIT.

CARRIER.—An arrangement for holding film or paper sensitive surfaces, when exposed in the camera in the same manner as the dry-plate.

A wooden framework so constructed as to allow the photographer to insert in the holder a smaller size of plate than that for which the camera is intended.

CARTE-DE-VISITE (abbreviated term *C de V*).—A small size photograph measuring about 2½ x 4¼.

CARTRIDGE.—Photographic chemical compounds are now sold in small cases of metal or paper similar to rifle cartridges. They are put up in this manner for convenience when travelling. The contents of one cartridge when dissolved in a specified quantity of water form a complete toning, fixing, or developing solution. Magnesium flash-light compounds are also made up in cartridge form.

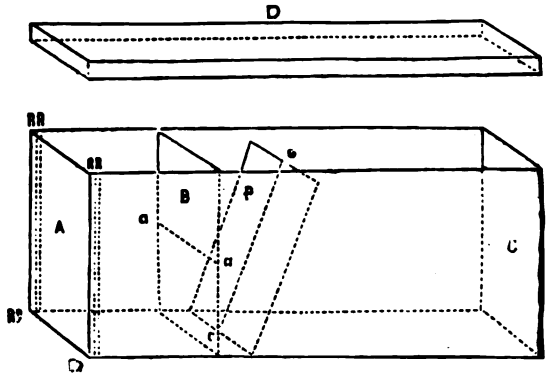


FIG. 99.—THE HAURONS "TRANSFORMISTE."

CASEIN.—An albumenoid substance found in milk. It is very similar to albumen. Casein dissolved in a weak solution of ammonia may be used for coating a plate. It gives a film less hard than albumen. Vegetable casein is found in the gluten of flour, peas, beans, etc.

CASKET LENSES.—See **Lens.**

CASSETTE.—A French term occasionally applied to the plate-holder of the camera.

CASTILE SOAP.—A fine, highly purified soap, originally made in Castile from olive oil and soda; soluble in alcohol and hot water. It is used in photography for lubricating prints previous to burnishing. For this purpose about three or four grains of the soap are dissolved in an ounce of alcohol. The solution thus formed is rubbed over the face of the print with a piece of flannel. Some operators prefer to rub a little of the soap itself on the print.

FIG. 101.—CARICATURE MADE WITH THE TRANSFORMISTE.

CASTOR OIL.—A thick oily liquid made from the seeds of the castor oil plant (*Ricinus communis*). Insoluble in water, soluble in ether and alcohol. It is used in the preparation of collodion and varnishes, to render them tougher, and in rendering paper or paper negatives transparent.

FIG. 100.—CARICATURE MADE WITH THE TRANSFORMISTE.

CATADIOPTRIC.—Pertaining to or involving both the reflection and refraction of light, as or in a catadioptric telescope.

CATALYSOTYPE.—A calotype process, in which paper is first prepared with a syrup of iron iodide instead of the ordinary potassium iodide. After exposure, the paper is developed by merely keeping it moist. It was supposed that the reason of this change was due to a catalytic* action on the silver salt caused by the light, hence the name catalysotype. The correct theory is, however, that the paper when treated with the silver, proto-nitrate of iron is

* A chemical change brought about in a compound by an agent that itself remains stable.

formed by the same decomposition which produced silver iodide, and this proto-salt being a still more energetic developer than gallic acid the latent image became visible. The process is, however, very defective, and not used now. It was invented by Dr. Woods.

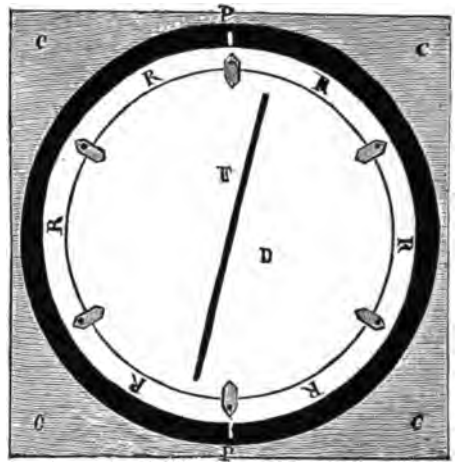


FIG. 102.—REVOLVING SLIT.

CATECHOL.—See **Pyrocatechin.**

CATHARIZATION.—The process of making a surface chemically clean.

CATHODOGRAPHY.—A name that has been given to the discovery of Professor Roentgen that certain rays (provisionally termed X-rays), will affect a photographic plate through substances otherwise considered opaque. It is so named because it is supposed that the rays proceed from the cathode or negative pole of the vacuum tube. This supposition is contradicted by many scientists. See **X-Ray.**

CATOPTER.—A reflecting optical instrument.

CATOPTRICS.—That branch of optics relating to reflected light.

CAUSTIC.—Chemical substances which destroy the animal tissue if applied to the flesh. The most commonly used caustics are caustic ammonia, caustic potash, and caustic soda.

CELLOIDIN.—A pure form of pyroxyline is sold under this name.

CELLOIDIN PAPER.—This term is sometimes applied to collodion printing-out papers. See **Collodio-chloride Printing-out Process.**

CELLULOID (Symbol, *Xylonite*).—A mixture of soluble pyroxylin with camphor, made by adding pyroxylin to melted camphor, by strongly compressing the two substances together, and by dissolving the two in a mixture of ether and alcohol, and evaporating. It was first made by Hyatt, of Newark, U. S., and takes the name celluloid from its having, when viewed under the microscope, the appearance of little cells.

The simplest method of manufacturing celluloid is by dissolving 50 parts of camphor in as little a quantity of alcohol as possible, and sprinkling this solution over dry pyroxylin; then cover over with a second lay of pyroxylin, and again sprinkle the camphor solution over it; 100 parts of pyroxylin should by used. By this means the celluloid mixture is made, and sinks in transparent lumps, which must be worked for about an hour between cold iron rollers, and afterwards for another hour between rollers which can be heated with steam. The layers of celluloid thus formed are placed one above the other and pressed in a hydraulic press at a temperature of about 70 deg. C. for about twenty four hours. The cakes are then cut into smaller cakes, and dried for eight to fourteen days in a room heated to about 35 deg. C.

Celluloid is an ivory-like material, and can be turned in a lathe like ivory, or if heated to about 175 deg. Fahr. can be moulded into any shape or form. It is highly inflammable unless mixed with a substance of an opposite character. It is non-explosive.

CELLULOID FILMS. Films of celluloid (*q. v.*) may be coated with a gelatine sensitive emulsion, the celluloid taking the place of the glass of the photographic dry plate, the advantage being in the reduction of bulk and weight. Celluloid film has been recommended as superior to ground glass for the focussing screen of a camera. The image is finer and the chance of breakage done away with.

CELLULOSE (Formula, $C_6H_{10}O_5$).—A substance constituting the basis of vegetable tissues. Cotton, hemp, flax, etc., are the commercial varieties of it. Cotton wool boiled with sodium carbonate, to free from resinous matters, is nearly a pure form of cellulose, so is paper made from rags. Swedish filtering paper is one of the purest kinds. Hot sulphuric acid will convert it first into dextrine and then to dextrose. Cellulose as cotton wool is employed in photography chiefly for the manufacture of pyroxylin. For this purpose that known as long fibre Sea Islands cotton is preferred by most makers.

CELSIUS THERMOMETER.—See **Centigrade Thermometer.**

CEMENT.—A good cement for mending glass, etc., may be made by dissolving isinglass in warm water and adding acetic acid. This cement is sold under the name of coaguline and other fancy names.

Cement for Wood to render Watertight.—A good cement for wooden vessels that are required to be made watertight can be produced with a mixture of lime-clay and oxide of iron.

These should be separately calcined and reduced to a fine powder. They are then well mixed together, kept in a closed vessel, and mixed with the required quantity of water when used.

Cement for Iron Pots.—Into an old iron pan place two parts of sulphur, hold over the fire until melted, then add one part by weight of fine black lead. Stir them well together until well mixed, and pour on to an iron plate or smooth stone. When cool break into small pieces. To mend a crack in a pot, put a small quantity of this composition on it, and solder with a hot iron in the usual manner.

A Cement for Indiarubber.—This can be made with:

Carbon-bisulphide	5 ounces.
Guttapercha	5 drachms.
Indiarubber	10 drachms.
Fish glue	25 drachms.

Cement for Lenses.—When two or more lenses are made to form a combination they are cemented together. Canada balsam is usually employed for this purpose owing to its transparency. It will sometimes happen after a number of years that this will become decomposed, and a delicate leaflike formation will take place commencing from the outer edges.

Some kinds of balsam turn yellow with age and the rapidity of the lens becomes lessened by this non-actinic color. Only the finest should be used for this purpose.

CEMENTING LENSES.—If through any cause the cement joining the lenses in a combination has discolored or become defective it should be removed and the lenses re-cemented. First remove from the mount and place in a convenient vessel—a saucepan will serve the purpose. To prevent the glass touching the bottom the lens should be wrapped up in stout flannel or a piece of wood be laid in the bottom of the pan. Lukewarm water is poured on to cover completely and this gently heated until the balsam is softened and the lenses can be separated. They are then carefully wiped and, when cold, cleaned with either benzole or oil of turpentine, using a very soft rag. This will remove all traces of the old balsam. They are then washed in soap and water. When quite dry they can be cemented together again. This is done by gently warming the lenses and laying one, concave side up, on a clean piece of cloth. A large drop of Canada balsam is applied to the centre, and the other lens laid on top and gently pressed so as to force the balsam equally in all directions until it oozes from the edges. They are then tied tightly together in a perfectly central position, and heat gently applied in a warm oven until the balsam at the edges is found to have hardened. This is then cleaned off with one of the solvents recommended and the lens is remounted.

CENTIGRADE THERMOMETER.—A thermometer generally used on the Continent. It is graduated on the scale of Celsius. The space between freezing point is divided into 100 parts, freezing point being marked at zero and boiling point 100 deg. In the Fahrenheit thermometer generally used in America, these points are 32 deg. aud 112 deg. respectively. To convert Centigrade into Fahrenheit it is necessary to multiply by 9, divide by 5, and add 32.

CENTIGRAMME (the hundredth part of a gramme).—A measure of weight used in the French decimal system of measurement. It is equivalent to .1543234 of a grain troy weight, or .16924 avoirdupois. The French decimal system of measurement is much superior to the American, and is being largely adopted in this country.

CENTILITRE or **CENTILITER.**—The one-hundredth part of a litre—a French measure of capacity or volume. It is equivalent to 2dr. 49min. English fluid measure, or ·6103 of a cubic inch.

CENTIMETRE or **CENTIMETER.**—The one-hundredth part of the French measure of length—the metre. It is equivalent to .03937, or about two-fifths of an inch.

CENTRAL SPOT.—See **Flare-Spot.**

CENTRE OF ADMISSION.—See **Optics.**

CENTRIFUGAL SEPARATION.—A process of separation used in the gelatine emulsion process. A machine is used which consists essentially of a revolving drum made to receive the emulsion (Fig. 103). If a liquid containing substances not in solution be made to rapidly rotate the solids not in solution will fly outwards from the center and adhere to the sides of the vessel. The cooked emulsion is placed in the drum, the machinery set in motion, and, after revolving for a sufficient length

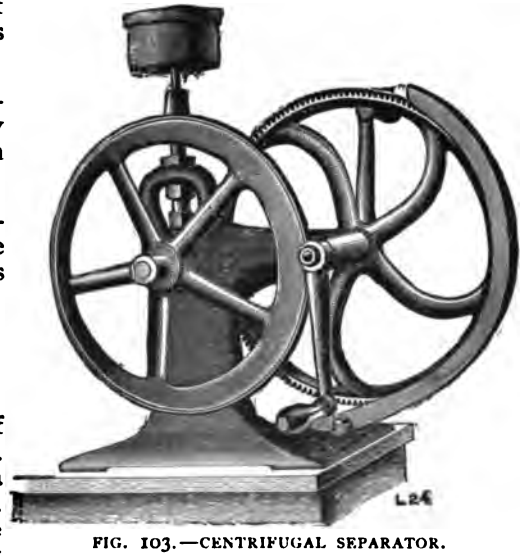


FIG. 103.—CENTRIFUGAL SEPARATOR.

of time, the silver haloids will be found to have separated. The liquid is poured off and the salts removed from the sides for use. See **Emulsion.**

CERAMIC PHOTOGRAPHY.—See **Photo-ceramics.**

CERIUM SALTS.—The two principal series of these salts are the cerous and the ceric. The first are stable, while the ceric are easily reduced. Messrs. A. & L. Lumière, taking advantage of this readiness of reduction of the ceric salts, have devised a printing process. The best results were obtained with ceric nitrate and sulphate formed by dissolving ceric hydrate in nitric and sulphuric acids. Well sized paper is coated with aqueous solutions of these salts. After drying in the dark, the paper is exposed beneath a positive. The action of the light is to reduce the ceric salts to the cerous state. The print is then treated with a suitable re-agent that will differentiate the cerous salt from the ceric and fix the image. Messr. Lumière mention the following: in acid solution the prints are colored gray with phenol, green with salts of aniline, blue with napthylamine, brown with amidobenzoic acid, red with parasulphanalic acid. Treated with ammonia the coloration changes.

CEROGRAPHY.—The art and process of engraving on wax.

CHALK.—A well-known substance, a massive opaque carbonate of lime. It is sometimes used in the toning bath. See **Toning.**

French Chalk.—Steatite, or soapstone. Powdered French chalk can be used as a lubricator for woodwork. It is also used to prevent gelatine or other similar substances from adhering to glass. If a clean sheet of glass be rubbed over with French chalk and afterwards coated with gelatine the film when dry can be easily removed from the glass. Powdered talc is also sold as French chalk, and for all photographic purposes is equally good.

CHANGING BAG.—A light-tight bag in which a number of plates may be kept and put with safety in daylight into dark slides for exposure. By this means the bulk and weight of carrying a number of slides is considerably reduced. Fig. 104 illustrates a form of changing bag patented by Ross and sold in England. It is made of several thicknesses of black and red material which are perfectly light-proof, and is furnished with an opening for the eyes, to which is attached a band of soft leather, which adapts itself exactly to the face, and is retained in position by two elastic straps that fasten at the back of the head by means of a hook and eye. In front is a window of three thicknesses of red material that admits a perfectly safe light, the amount of which can be regulated by fastening one or more of the hooks that keep up the blind, or by turning it to or from the light when in use. As no glass or other breakable material is used, the bag cannot be injured by being tumbled up in the camera case or pocket, and the mouth and nose being outside the bag, the breathing is not interfered with. In the small size the plates, etc., are put in through one of the sleeves, which is afterwards closed by an elastic band. The larger sizes are made to open at the bottom, and close by means of a flap that fastens between the folds of material that form the sides.

FIG. 104.—CHANGING BAG.

CHANGING BOX.—A light-tight box constructed for the same purpose as a changing-bag, *i. e.*, to refill the plate-holder with unexposed plates where a dark-room is unavailable. A changing-bag is to be preferred.

CHARCOAL, ANIMAL (synonym, bone-black).—Obtained by heating crushed bones in an iron retort. Insoluble in water; partly soluble in hydrochloric acid. It is employed in photography to deoderize offensive smelling blood-albumen paper.

CHEMICAL ACTION OF LIGHT.—See **Light.**

CHEMICAL AFFINITY.—See **Affinity.**

CHEMICAL ATTRACTION.—The same as chemical affinity, *q. v.*

CHEMICAL COMBINATION.—When two or more chemical substances combine to form a compound different from any of its constituents, and which cannot be separated by any mechanical means.

CHEMICAL EQUIVALENT.—The relative proportions in which chemical substances will replace one another according to their atomicity. One atom of oxygen is the chemical equivalent of two atoms of hydrogen.

CHEMICAL FOCUS.—A lens possesses two foci, the visual and the chemical. Before the many improvements in optical instruments were made these two foci differed; in some cases very considerably, so that it was necessary to determine the difference, and after focusing on the screen at the visual focus, to shift it to the chemical focus determined by photographic surfaces. In a good lens, however, these two foci should coincide. To test for chemical focus, place a few yards from the camera three cards with sharply defined letters on them, as in Fig. 105. Focus with a magnifying glass on the centre card, and upon developing carefully examine the image with a magnifying glass. If the centre card is the sharpest of the three, the lens has been properly corrected; but if the first card is the sharpest, the chemical focus is shorter than the visual. It will therefore be necessary to slightly push in the camera before exposure. If on the other hand the letters on the third card are the clearest defined, the defect is of an opposite character, the lens has been over-corrected and has a back focus. Traill Taylor gives the following method of visually testing for over or under-correction: "Bring the lens to be examined into a slightly darkened room in which there is a gas light burning, and retreating several feet from it hold up the lens so as to form an image of this light in the eye of the observer. The image must, however, be examined through an eye-piece of any good construction. At the point where the image is sharpest there is but little color, but by bringing the portrait lens a little nearer, the flame, if the lens be properly corrected, is seen to be surrounded with a claret fringe, while on removing it to a greater distance than distinct definition, the light is fringed with green, proving that the blue and yellow rays are combined, and, as a consequence, that the chemical and visual foci do coincide.

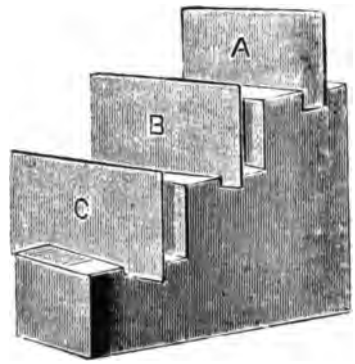


FIG. 105.—ARRANGEMENT FOR TESTING CHEMICAL FOCUS.

CHEMICAL FOG.—See **Fog.**

CHEMICAL FORMULÆ.—The symbolic expressions indicating the chemical constituents of a body, as NaCl indicates that sodium chloride contains 1 atom of chlorine and 1 atom of sodium.

CHEMICAL RAYS.—See **Light.**

CHEMICAL REAGENTS.—Absolutely pure chemicals used for analyzing or testing.

CHEMICAL RETOUCHING.—The principal of this method* consists in arresting the action of the developer on the parts of the negative which come up too rapidly. For this purpose, as soon as it is apparent that these portions are almost fully developed, the negative is removed from the developer, allowed to drain a moment, until there is no free liquid on its surface. Then all the portions where the detail is sufficient are painted by means of a camel-hair brush with a 5 per cent. solution of bromide of potassium. The gelatine absorbs this solution very rapidly, and the places may be gone over several times according as the detail is more or less out. The negative is then returned to the developer, and the development continued until the detail comes up in all portions of the negative. The development is nearly or quite arrested wherever the bromide was applied, and these portions do not gain in density. In the end a negative is obtained with detail throughout.

CHEMICALS.—See **Photographic Chemicals.**

CHEMICAL SENSITIZER.—Any substance which increases the photographic sensitiveness.

CHEMICAL SPECTRUM.—See **Spectrum.**

CHEMIGRAPHY.—A term applied to a process of making zinc etchings without the aid of photography.†

CHEMISTRY.—In a work of this kind it is impossible to deal with the history and progress of chemistry, but chiefly to define its objects. These are given in Professor Muller's elements as follows:

First, to resolve matter into its simplest componnds; 2d, to ascertain the properties of these simple or elementary forces of matter; 3d, to combine two or more of these elementary bodies with each other to form compounds; 4th, to study the properties of these compounds; and 5th, to define the conditions under which such compounds can exist. All these objects are embraced by pure theoretical and philosophical chemistry, which may be again divided into organic and inorganic chemistry. These we can also separate, the former into animal and vegetable, and the latter into metallurgical, agricultural, and medical chemistry. By applied chemistry, we mean the application of chemical principles to the various substances used in ordinary life; and by technical chemistry that which relates to our arts and manufactures.

* G. Mareschal in "Photo Gazette."
† This term has also been applied to a method of printing half-tones in two colors, one being slightly out of register.

The subject of chemistry is matter which exists in one of three states, *i.e.*, solid, liquid, or gaseous. In the solid state, the molecules are closely pressed together. In the liquid, they are not closely pressed, but can move freely about each other. In the gaseous state, matter is the most porous, the molecules having so little attraction for each other that, were it not for the pressure of the surrounding bodies, they would separate altogether.

Before proceeding farther it will be well to explain the theory of atoms and molecules, and elements and compounds. In nature we have simple and compound bodies. The first are called elements, which is a substance or gas which is not composed of more than one constituent —in other words, *it is itself* a compound of particles which are perfectly identical. In a compound this is not the case, as two or more elements are required. By analysis the chemist pulls to pieces every compound by separating its constituents until he arrives at the elements which refuse to be separated. We will take, for instance, a piece of alum. By separating its component parts we find that it contains oxides of aluminium and potassium, sulphuric anhydride, and water. These substances we can again separate, and we find that they contain aluminium, potassium, sulphur, oxygen and hydrogen. These we cannot divide, because they are not compounds of various substances as the others are, but complete in themselves, and refuse to be divided. These are called elements. There are about seventy of these simple bodies or elements known, but many of them are of no practical or commercial use. The photographer has only to do with about twenty-five. A complete list with their symbols, atomic weights, and derivations will be found under **Elements.** These elements may be divided into two classes—the metallic and the non-metallic—and in chemistry are represented by an appropriate letter or combination of letters, which is termed a symbol.

The idea that matter is composed of atoms was expressed by Democritus and other Greek philosophers; but it was not until 1804 that the English chemist, Dalton, laid down the following laws, the result of his researches, and which form the basis of our present ideas of chemical combination.

All substances are capable of separation into minute particles until a point is arrived at at which divisibility ceases, the resulting particles being called molecules, which in turn are made up of more minute portions of elements called atoms, the atom of an element being the smallest quantity capable of existence and retaining its identity.*

Atoms combine with each other in a fixed and definite proportion by weight and volume, We can prove this. Water invariably contains oxygen and hydrogen in certain proportions, *i. e.*, 16 parts (by weight) of oxygen and two parts (by weight) of hydrogen. These are proportions in which oxygen and hydrogen combine to form water.

As compound bodies are produced by the union of a given number of such atoms, it is evident that the molecules of which these compounds are made up must in their turn possess a fixed and definite combining portion by weight and volume.

For an example of this law we take the compounds of oxygen and nitrogen. The simplest relation in which these two elements combine is in the proportions of 28 of nitrogen and 16 of oxygen, forming nitrous oxide. The next compound, nitric oxide, contains 28 of nitrogen and 32 of oxygen; the third, nitrous anhydride, 28 to 48; the fourth, nitric peroxide, 28 to 64; and the fifth nitric anhydride, 28 to 80. Here it will be seen and it is exceedingly instructive, that the nitrogen remains constant, while the oxygen unites in the proportions 16, 32, 48, 64, 80, which are all multiples of 16, the simplest proportion. This law is known as the law of combination in multiple proportions.

If a body is capable of uniting with another in more than one proportion, these proportions representing the weights of the several atoms must necessarily be simple multiples of the weights of any one of them.

In the list of elements we have also their atomic or combining weight. Hydrogen, being the lightest body known, is taken as unity. Its combining or atomic weight is therefore stated as 1, the other numbers corresponding to the different elements given in the table are the proportions by weight in which the other bodies are found to combine with it.

We have next to deal with chemical attraction, which is a force exerted between atoms, causing them to combine together, and producing a complete change in the bodies affected. A chemical compound differs entirely from mechanical mixture. We may powder sugar and potassium chlorate and mix them together in any proportion, but they are not chemically united, for by digesting in spirit we can dissolve the sugar, leaving the potassium chlorate as it was. But if we add to the mixture a drop of sulphuric acid, the whole mass inflames, leaving a residue from which it is impossible to recover the sugar or the potassium chlorate. Here we have a true chemical combination.

Chemical action is invariably accompanied by an alteration in the temperature of the substances combining. In many this is not appreciable, but if sulphuric acid be added to water contained in a test-tube held in the hand the heat caused by the combination will soon be painfully apparent.

* The chemical definition of an atom is that it is the smallest particle that can take part in a chemical compound; and of a molecule, that it is the smallest particle of an element or compound that can exist alone (under ordinary circumstances). The smallest molecule contains two atoms, although under certain conditions the atom and molecule are identical.—A. B. Aubert.

In the column of elements we find opposite to the name of each element the symbol which is always employed to represent it. This symbol not only represents the particular element, but a certain quantity of it. The letter H stands for one atom or one part by weight of hydrogen; the letter N for one atom or fourteen parts by weight of nitrogen; and the symbol Cl for one atom or 35.46 parts of chlorine. If these elements be made to combine together to form a compound, the compound must in like manner be represented by writing the symbols of its constituent elements side by side, and if more than one atom of an element be present the number is placed at the right of the symbol either above or below the line. Thus, hydrochloric acid is represented by the formula HCl, which signifies that it is a compound of one atom of hydrogen with one atom of chlorine, or one part by weight of hydrogen with 35·46 parts by weight of chlorine. Sulphuric acid is represented by the formula H_2SO_4 or H^2SO^4, which shows to the chemist that it consists of two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen.

The relation of bodies to each other in atom-fixing power is called valence. Valence may, therefore, be considered as the measure of power which one atom possesses of invariably attracting to itself a given number of atoms. This value, which also has hydrogen as unity, must not be confounded with the atomic weight. Atoms which are capable of fixing only one atom of hydrogen to form a compound are called monads, those which can fix two atoms of a monad are called dyads, those which can fix three atoms of a monad are called triads, those which can fix four atoms of a monad are called tetrads, those which can fix five atoms of a monad are called pentads, and those which can fix six atoms of a monad are called hexads. The valence of bodies is represented by small ticks or Roman figures placed over the symbol, thus:

Monad	H i.
Dyad	O ii.
Triad	B iii.
Tetrad	C iv.
Pentad	P v.
Hexad	S vi.

The following table gives the valence of a few of the most important elements. Some of them it will be seen occur two or three times—the reason of this is because they form two or three series of compounds:

Monads.	Dyads.	Triads.	Tetrads.	Pentads.	Hexads.
1	2	3	4	5	6
H	O	Au	Pt	N	S
K	Ca	N	C	As	
Na	Hg	Fe	S	Sb	
Li	Ba				
Ag	Pb				
Cl	Zn				
Br	Mg				
I	Cd				
Am	Cu				
Hg	Fe				
	S				

Let us illustrate the mode of using this table to arrive at the formula of any known compound. If it is desired to write sodium chloride we find that sodium (Na) is a monad, and so is chlorine (Cl). Both elements have equal valence; therefore, it is written NaCl. In determining the formula of gold chloride, we find that gold (Au) is a triad, and chlorine a monad; therefore, the latter must be multiplied by three to make it balance the former, or, in other words, the gold is equal in combining power to three atoms of chlorine, the formula being $AuCl_3$. Oxide of gold would be one and a half atoms of oxygen to one atom of gold, but as we cannot halve an atom the formula is written Au_2O_3.

It has already been pointed out that some of the elements occur two or three times in the table. In such cases, those compounds in which the metal has the lower valency have the termination ous to the metal, while those with the higher combining power terminate in "ic." Thus, ferrous chloride, $FeCl_2$; ferric chloride, $FeCl_3$.

Let us now sum up what we learn from these theories. First, that an *element* is a substance complete in itself, and cannot be analysed. It is represented by a *symbol*, which indicates when written *one atom* of the element, one *atomic weight*, which represents the unalterable quantity in which it combines with other substances by weight, *the valence* or *combining power* of the atom with other atoms, and *a volume* in the gaseous state equal to a single volume of hydrogen. Secondly, we learn that a *compound* or an element in a free state is produced by the union of two or more atoms. It is represented by a *formula*, which in its turn represents *one molecule* of the compound, *one molecular weight* equivalent to the sum of the atomic weights of the elements of which it is composed, its *valence* or combining value with other substances, *a volume* in the gaseous state equal to two volumes of hydrogen.

CHEMISTRY OF PHOTOGRAPHY.—See Photographic Chemistry.

CHEMITYPE.—A process of making colored photographs, devised by C. A. Seely. Two collodion positives were made, one of them was colored and placed behind the other and the whole backed up with white paper.

CHIAROSCURO.—A term used in art to denote the distribution of the lighter and darker shades in a picture.

CHINOLIN BLUE.—See **Cyanin.**

CHINOLIN RED (Formula, $C_{26}H_{19}N_2Cl$).—A dark red powder, soluble in water and sensitive to light. It is used as a color sensitizer in orthochromate photography (*q. v.*).

CHLOR-ACETIC ACID.—Acetic acid in which hydrogen has been replaced by chlorine.

CHLORATE OF POTASSIUM.—See **Potassium Chlorate.**

CHLOR-HYDRIC ACID.—See **Hydrochloric Acid.**

CHLORIDE.—A compound of chlorine with an element or radical. See **Chlorides, tests for**

CHLORIDE OF ALUMINIUM.—See **Aluminium Chloride.**

CHLORIDE OF AMMONIUM.—See **Ammonium Chloride.**

CHLORIDE OF CADMIUM.—See **Cadmium Chloride.**

CHLORIDE OF CALCIUM.—See **Calcium Chloride.**

CHLORIDE OF COBALT.—See **Cobalt Chloride.**

CHLORIDE OF COPPER.—See **Cupric Chloride.**

CHLORIDE OF GOLD.—See **Gold Trichloride.**

CHLORIDE OF IRIDIUM.—See **Iridium Chloride.**

CHLORIDE OF LIME.—See **Calcium Chloride.**

CHLORIDE OF LITHIUM.—See **Lithium Chloride.**

CHLORIDE OF MAGNESIUM.—See **Magnesium Chloride.**

CHLORIDE OF MERCURY.—See **Mercurous Chloride.**

CHLORIDE OF PALLADIUM.—See **Palladium Chlorlde.**

CHLORIDE OF PLATINUM.—See **Platinum Chloride.**

CHLORIDE OF POTASSIUM.—See **Potassium Chloride.**

CHLORIDE OF SILVER.—See **Silver Chloride.**

CHLORIDE OF SODIUM.—See **Sodium Chloride.**

CHLORIDE OF STRONTIUM.—See **Strontium Chloride.**

CHLORIDE OF ZINC.—See **Zinc Chloride.**

CHLORIDE PAPER.—Paper coated with a gelatino-chloride emulsion. For a suitable chloride emulsion see **Emulsion.** This term is also applied to albumen paper containing a chloride.

CHLORIDE PLATES.—Plates coated with a chloride of silver gelatine emulsion, and used for transparencies and lantern slides. For the emulsion see **Emulsion,** and for the manipulation of the plates see under **Transparencies.**

CHLORIDES, TESTS FOR.—Chlorides can be detected by completely precipitating with silver nitrate and digesting the well washed precipitate with a 10 per cent. solution of ammonium hydroxide. If a chloride is present the filtrate will turn milky if supersaturated with nitric acid.

CHLORINATED LIME.—See **Lime Chloride.**

CHLORINE (Symbol Cl. Atomic, weight 35.5).—The elementary substances, chlorine, bromine, iodine and fluorine, are called halogens, because they produce with other elementary substances bodies resembling almost in every respect the so-called oxysalts. Cyanogen, a compound radical, is often likened to the true halogens on account of it possessing properties similar to them.

Chlorine never occurs in a free state, but when combined with sodium it is found abundantly in the earth, in solid and crystallized states in mines, dissolved in the sea water, in salt springs, in river water, and more or less in every organic being.

Chlorine gas is of a greenish-yellow color, of penetrable odor, irrespirable, causing inflammation of the lungs, and finally death.

Water absorbs large quantities of the gas (2 volumes). The liquid known as chlorinated water has all the properties of the pure gas, and when standing for a length of time, deposits a yellowish crystalline precipitate—hydrate of chlorine.

For the preparation of chlorine gas the decomposition of hydrochloric acid by means of peroxide of manganese has been selected. The oxygen of the peroxide combines with the hydrogen of the hydrochloric acid, forming water, the manganese and chlorine form manganese chloride and chlorine is set free. The other, and probably the most widely adopted method is to heat sea salt with peroxide of magnesium and sulphuric acid.

$2NaCl$	+	$2SO_4H_2$	+	MnO_2	=	$2Cl$	+	Na_2SO_4	+	$MnSO_4$	+	$2H_2O$
Sodium chloride		Sulphuric acid		Manganese peroxide		Chlorine		Sodium sulphate		Manganese sulphate		Water.

Chlorine is not combustible, and one of its most remarkable properties is its power to combine with hydrogen to form hydrochloric acid. This acid is a colorless gas, is soluble in water, and one volume of it absorbing 454 volumes of the gas. This is the crude hydrochloric or muriatic acid, containing iron, arsenic and sulphuric acid. Rectification produces a chemically pure article, as used by analysts and photographers.

A mixture of hydrochloric acid with nitric acid is termed aqua regia, because gold can be dissolved with it. Its solvent action depends upon the fact of containing free chlorine, liberated by the action of oxygen upon the nitric acid. The metal combines directly with this free chlorine, and soluble chlorides are formed.

Chlorine combines, but indirectly, with oxygen, giving rise to the following oxyacids of chlorine:

Hypochlorous acid, or hydrogen hypochlorite, HClO. Chlorous acid, or hydrogen chlorite, $HClO_2$. Chloric acid, or hydrogen chlorate, $HClO_3$. Perchloric acid, or hydrogen perchlorate, $HClO_4$.

Hypochlorous acid finds employment in photography as a bleaching agent and a powerful hyposulphite of sodium eliminator. The combinations with sodium, potassium and zinc are well known and appreciated. Chlorine peroxide and chlorous acid have not entered into photographic practice, but chloric acid or hydrogen chlorate is, in the form of potassium chlorate, very much used as an ingredient in various flash-light compounds, on account of its explosive properties.

When potassium chloride is heated to fusion a new salt, potassium perchlorate, is formed, $KClO_4$. Perchloric acid and its salts are extremely powerful oxidizers, and have for that reason been recommended as ingredients for flash-light powders. But their force of explosion is so very violent that their employment has been but very limited and has finally been totally abandoned.

Of chlorine combinations highly interesting to the photographer and useful to him in a variety of ways are terchloride of gold, chloride of gold, and sodium or potassium, chloride of silver, ammonium or potassium or sodium chloride, chloride of calcium or chloride of lime, a mechanical mixture of hypochlorite of lime and calcium chloride. Ferric chloride plays an important part in many of the lichtdruck processes, and is sometimes used as an intensifier, at other times as a reducer. Chloride of copper has been recommended as a reducer, and there are many others of more or less importance to the student.

CHLORO-BROMIDE EMULSION.—An emulsion containing both a chloride and a bromide.

CHLOROFORM (Formula, $CH Cl^3$; molecular weight, 119.52; synonyms, *methenyl chloride*, *formyl chloride*).—Chloroform is prepared by the distillation of a mixture containing bleaching powder, slacked lime, water, and alcohol. The alcohol and water are added together and warmed in a still fitted with a condenser. The bleaching powder is then added and temperature increased until chloroform begins to come over, after which the distillation becomes complete by the heat evolved in the reaction. Chloroform is also largely prepared from rectified spirit and methylated spirit. The purest quality is that prepared by the action of alkalies on previously purified chloral.

Chloroform is a liquid having a sweet pleasant taste and an agreeable ethereal odor. It dissolves in all proportions in alcohol and ether and slightly in water. It burns with a green smoky flame.

Chloroform is used in many photographic operations, chiefly on account of its properties as a solvent for alkaloids, as well as for iodine, bromine, camphor, resins, indiarubber, sulphur, fats, and many other organic bodies.

It is sometimes adulterated with alcohol, wood spirit, methylated chloroform, and sulphuric acid. These impurities may be detected by addition of ferrous di-nitro sulphide, prepared by acting on ferric chloride with a mixture of potassium nitrate and ammonium sulphide. If it acquires a green color, the impurities already mentioned are present

Chloroform should be kept in a dark place, for if exposed to air and sunlight it resolves itself into hydrochloric acid, chlorine and other products, unless it be entirely free from nitryl compounds.

CHLORO-IODO-BROMIDE EMULSION.—An emulsion containing a chloride, an iodide, and a bromide.

CHLOROPHYL.—The peculiar substance to which the green color of the leaves, fruit and other parts of plants is due, and the nature of which, notwithstanding the extent of the researches that have been made, is still doubtful. It dissolves in alcohol and ether, but not in water. Its properties are neutral, being neither of an acid nor a base.

Pelletier was the first to give the substance its name, and thought it to be a peculiar proximate principle; later on he found it to be a mixture of wax and a green colored oil. Mons. Fremy succeeded, by the joint action of two parts of ether and one of hydrochloric acid, diluted with water, to separate chlorophyl into two distinct coloring principles, which he called phylltanthin, because of its yellow color, and the other phyllocyanine because of its blue. If these two are separated from their solution and reunited, the result is a green color, the chlorophyl of the first instance.

Under the continuous action of light and heat upon vegetables, chlorophyl splits into these constituents, by which the change of color in autumnal leaves is easily explained. That not all leaves turn to a bright yellow or orange, like those of the maple tree, has its reason in the fact of the presence of certain chemical reagents. Tannin in the oak leaves for example makes the color a yellowish brown, the leaves of the willow turn almost white because of the salicine present Rhus, clematis, and other plants turn from bright red to a lively purple for similar reasons.

Becquerel was the first to use chlorophyl for photographic purposes, as a red sensitizer. Ives followed in 1879,* and perhaps employed it far more extensively than any other photographer ever did. But chlorophyl gave satisfactory results mainly in the wet collodion process; with gelatine emulsion plates it was far less useful.

Experimenters have stated that chlorophyl forms an intimate combination with caustic alkalis, and is, in that state, a fine sensitizer for red.

Chlorophyl has, however, been superseded by more convenient reagents, like chinoline blue, or malachite green, and at present little is heard of it.

Books on chemistry, and our own experience, have proved that the best source to obtain the substance is spinach leaves. Ives made it from "vinca minor," called by a provincial name, garden myrtle.

To make chlorophyl, fresh and juicy leaves of plants are pounded in a mortar, and, when reduced to a pulpy state, the liquid is separated from the solids by filtration or straining. When digesting this liquid with ether, chlorophyl and waxy substances are dissolved. They are evaporated to dryness, and by a treatment with alcohol the waxy substances will separate. The solution, after being filtered, is again evaporated to dryness, and dissolved in strong hydrochloric acid, which gives a solution of beautiful *green* color with a very lively *red* fluorescence.

Marble dust, carbonate of calcium, throws from this solution a flocculent green precipitate, not soluble in water.

The chemical constitution of chlorophyl has not yet been fully determined upon, but it contains much nitrogen.

Chlorophyl has also been found in the animal kingdom, in animals of the lowest order.

Solutions of chlorophyl show a bright green color and an absorption spectrum that is exceedingly interesting and characteristic. It absorbs nearly the whole spectrum, only a narrow strip of light at the extreme red being visible. This peculiar property has made it of great use in orthochromatic photography in rendering silver bromide more sensitive to the red end of the spectrum. Ives' process is entirely based upon the uses of this substance. See **Orthochromatic Photography**.

CHLORO-PLATINITE OF POTASSIUM.—See **Potassium Chloroplatinite.**

CHLOROPLATINOUS ACID.—See **Platinous Chloride.**

CHROMATE OF LEAD.—See **Lead Chromate.**

CHROMATES (salts of chromic acid).—Solutions of chromates give a yellow precipitate with barium nitrate, a dark red precipitate with silver nitrate, and a yellow precipitate with lead nitrate.

CHROMATIC ABERRATION.—See under **Aberration** and **Achromatism.**

CHROMATICS.—Relating to color or colors. The science which explains the various portions of the colors of light and of natural bodies.

CHROMATIC STEREOSCOPY.—See **Stereoscopic Photography.**

CHROMATYPE.—A name given to a class of processes based upon the deoxidization of chromic acid. The original process was worked by soaking well-sized paper in a saturated solution of bichromate of potash, and dried rapidly in front of a fire away from daylight. The

* Herr C. Jacobi, of Venice, claims to have employed chlorophyl as a color-sensitizer as far back as 1877.

paper is then of a bright yellow color, but exposure to the sun under a negative darkens the exposed portions to a deep orange, and water will remove the unchanged parts. The process has now been perfected as the carbon process, *q.v.*

The name was also given by Professor Hunt to a process of obtaining positive prints as follows: One dram of copper sulphate is dissolved in an ounce of water and half an ounce of a saturated solution of bichromate of potash added. Paper is coated with this and exposed to light. It first turns brown, and a negative picture is obtained. By a prolonged exposure a yellow positive picture on a white ground is produced. The paper is washed over with a solution of silver nitrate. The image is fixed by washing in water, but it is not permanent.

CHROME ALUM.—See **Alum.**

CHROME YELLOW.—See **Lead Chromate.**

CHROMOCOLLOTYPE.—See **Collotype.**

CHROMOPHOTOGRAPH.—A name given by Woodbury to a process of producing colored photographs. A lithograph was first made printed in two or three colors. A photomechanical image was then printed over this by the Woodburytype process. The color appearing through the image gave the chromatic effect.

The term chromophotography is generally applied to any process of producing colored photographs.

CHRONO-PHOTOGRAPHY (synonym, photo-chronography).—A term applied to the photography of objects or animals in motion at regular intervals of time. Muybridge, Dickson, Edison and Jenkins of this country, Marey of Paris, and Anschütz of Lissa, have made a special study of chronophotography, and the value of their researches in the science of motion cannot be over-estimated.

For making chrono-photographs we require a camera capable of making a number of successive exposures. There are several kinds.

Professor Marey's apparatus is arranged so that a number of successive exposures can be made upon one roll of sensitive film which passes behind the lens. In order that the negatives should be sharp it is, of course, necessary that the film be motionless during exposure. Where the intervals of exposure are very short (forty or fifty a second), the rate of motion of the mechanism is necessarily very rapid. Of course it would be out of the question to stop this motion suddenly; equally so to stop the motion of the film while the spools kept on working; and the difficulty has been surmounted very ingeniously by Professor Marey. At the point where the film passes behind the lens, a compressing-roller forces it for an instant against the central partition, thus arresting its movement. But, before reaching this point, the film passes around a flexible plate, against which presses a spring, the result of which is this: that while the film is momentarily arrested, back of the lens, the spool continues to unwind, and the slack, so to speak, is taken up into a loop, by the plate, actuated by the spring; when the film is liberated this loop flies into position and makes its momentary stay while the flexible plate comes back to its original position and again takes up a loop of the film, and during the successive exposure.

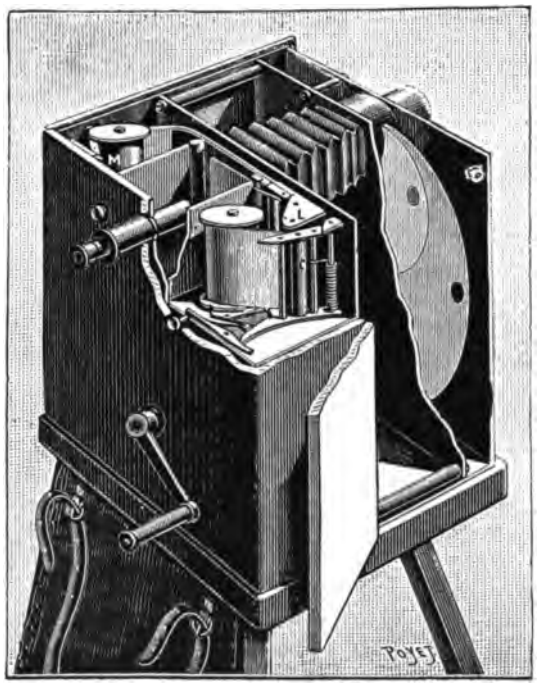


FIG. 106.—PROF. MAREY'S CHRONOGRAPHIC APPARATUS.

In order that the actuating machinery may attain a uniform speed before any exposures are made, it is arranged to be thrown in and out of gear, so that the handle can be turned without moving the spools.

The apparatus used by Londe is constructed on a different plan. It consists of a battery of lenses, each provided with a shutter. By an electric attachment these lenses can be fired off in rapid succession.

In Fig. 107, A is the covering plate carrying the objectives, shutters and electric gearing; B, thirteen-wire contact; C, camera; D, focusing rack.

Fig. 108 shows the current distributor. A, clockwork case; B, brush; C, ivory disk; D, one of the twelve contacts; E, insulating tube; F, the twelve wires connected with the terminals G, G; G^1, return wire; H, escapement; I, armature; J, electro magnet; L, regulation of the counter spring; N, terminals for the current of the transmitter.

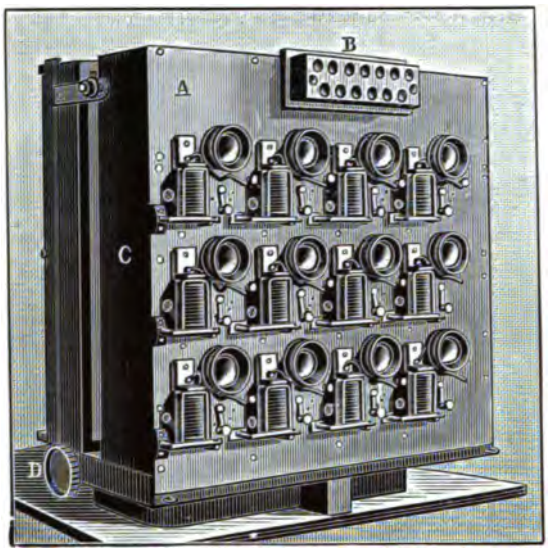


FIG. 107.—CAMERA.

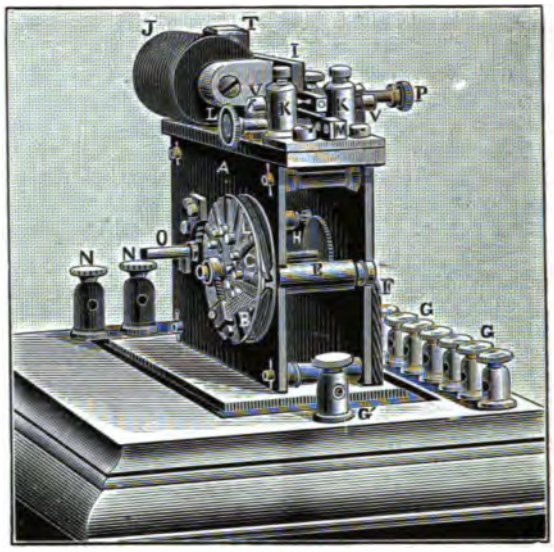
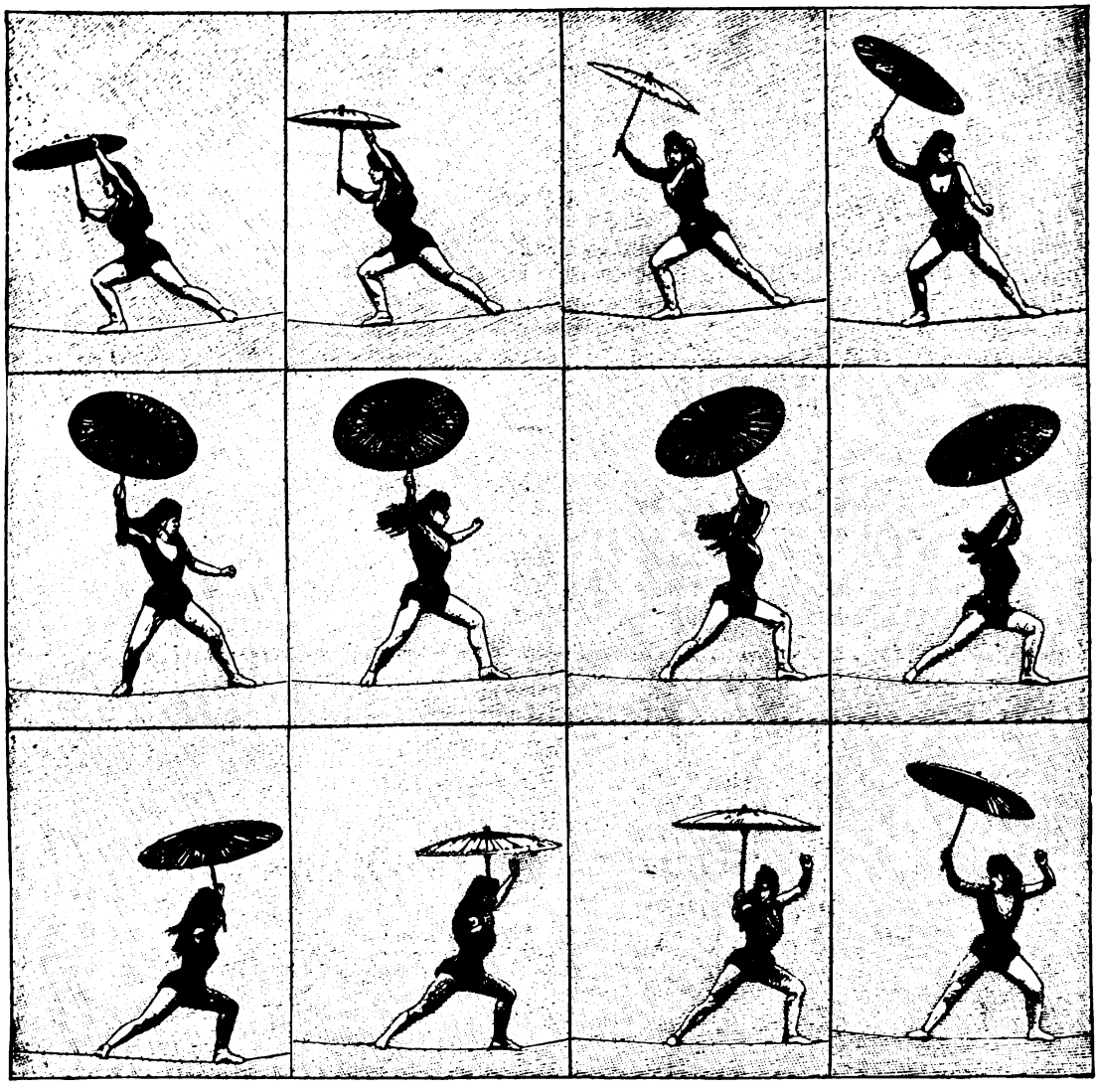


FIG. 108.—DISTRIBUTER.



From "The Scientific American."

FIG. 109.—FACSIMILE OF A PHOTOGRAPH TAKEN BY MR. LONDE'S PHOTO-CHRONOGRAPHIC METHOD.

The camera is provided with twelve objectives arranged in three parallel rows so as to give the twelve images upon a 9 x 12 plate. Each objective is provided with a shutter of the Londe & Dessoudix system.*

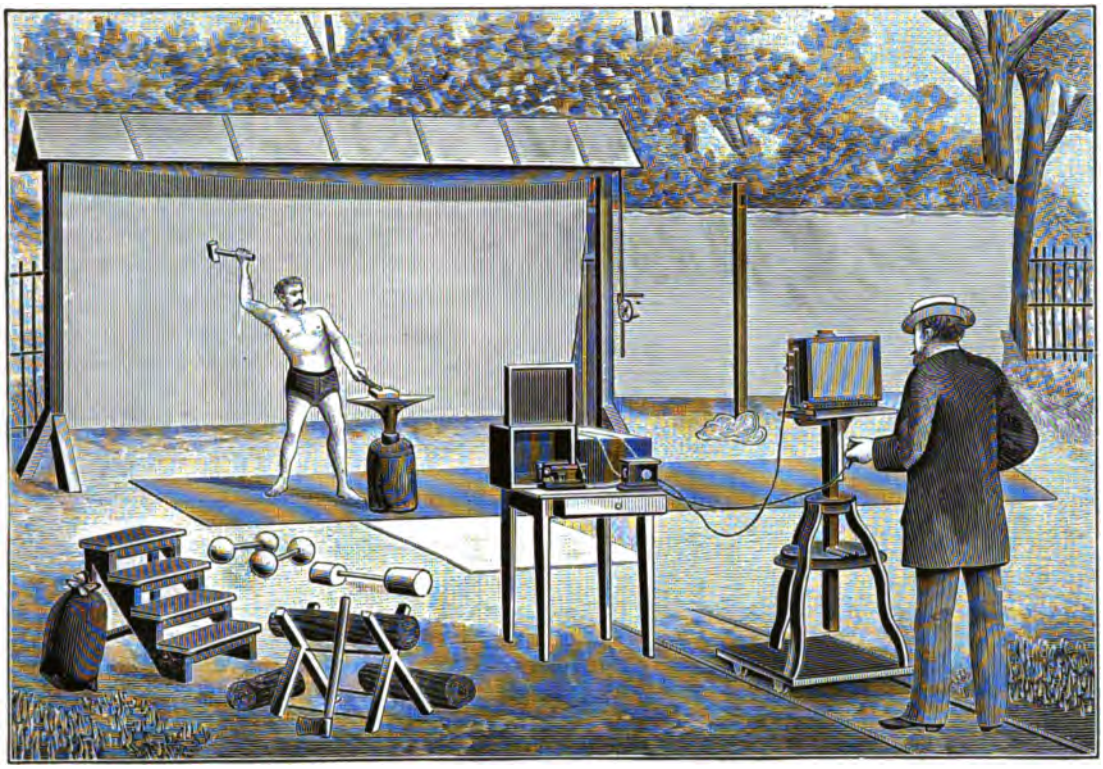


FIG. 110.—AN OPEN AIR PHOTOCHRONOGRAPHIC LABORATORY AT SALTPETRIERE.

The freeing of the shutters is done electrically. Fig. 108 shows the electro-magnets and their armatures placed near each objective. The connection of the various wires is effected at a single stroke by means of the piece, B, which is put in communication with the distributer by means of a flexible 13-wire cable, twelve of the wires being in communication with the twelve electro-magnets, and the thirteenth serving as a common return wire.

The apparatus is mounted upon a laboratory stand or a field stand, permitting of transporting it with sufficient facility.

Monsieur Marey has made a complete study of the motion of all kinds of animals. He employs a very ingenious method, in some cases to avoid the confusion from the superpositives of images when using fixed plates. Such parts of the object as are not required are blackened so as to become practically invisible while those parts the movements of which are to be studied are picked out in white. In the study of the motion of a man for instance, he dresses him up in black velvet as shown in Fig. 113, with light spots and stripes on his limbs. In the chronophotograph (Fig. 111) all the positions assumed by the limbs are indicated by white lines. The number of images is considerable while the space occupied is considerably limited without confusion.

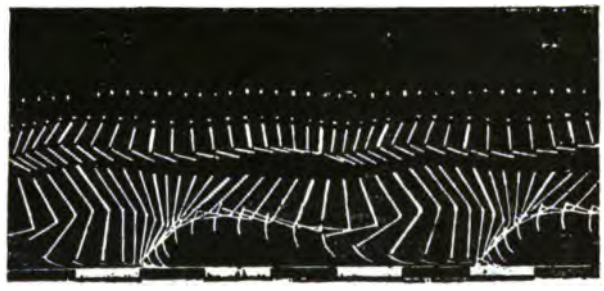


FIG. 111.—IMAGE OF A RUNNING MAN.†

Some years ago Mr. Stanford, formerly Governor of California, believing that the various positions assumed by a horse in executing its different paces were but little known and could only

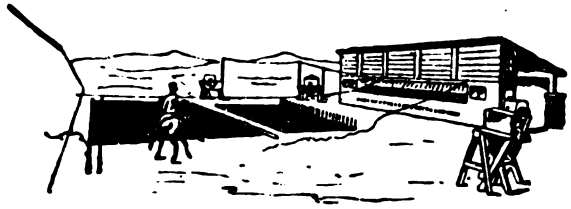


FIG. 112.—MUYBRIDGE'S ARRANGEMENT FOR PHOTOGRAPHING THE MOVEMENTS OF A HORSE.

* This description of Mr. Londe's apparatus is taken from the *Scientific American*. † From "Le Mouvement" par E. Marey.

be ascertained by means of photography sought the assistance of Muybridge who succeeded in making some remarkable photographs. The arrangement employed is shown in Fig. 112. On the left is a white inclined screen reflecting the sunlight and marked with divisions at equal distances for convenience in measurement. A series of cameras was arranged on the opposite side and fine electric wires were stretched across the path. These latter were connected with the shutters of the camera. As the horse passed it broke the wires which set off the shutters of each camera in succession and a series of photographs was thus obtained showing the various attitudes assumed by the animal.

In a book entitled "Le Mouvement," M. Marey details his method of obtaining chronophotographs of animals and gives reproductions of photographs obtained, illustrating almost every kind of living creature. Some of these we reproduce here.

Fig. 116 shows a *Medusa*, or jelly-fish. They are transparent. The motion of these animals is produced by the alternate dilation and contraction of the upper part of the body, which resembles in shape a toadstool. The movements are slow and can almost be followed with the unaided eye. When expanded, water is drawn in, which is expelled by the contraction, and the animal is propelled in the opposite direction. The specific gravity of these animals being almost the same as that of the medium in which they live, they need to exert but little power to propel themselves. Only ten exposures per second are necessary in order to examine the motion of the animals, and in the twelve pictures can be clearly seen the phases from the dilated condition of the head to that where it is contracted. The exposure was made with the illumination coming from above, and against a dark background.

FIG. 113.—MAN DRESSED FOR CHRONOPHOTOGRAPHY.*

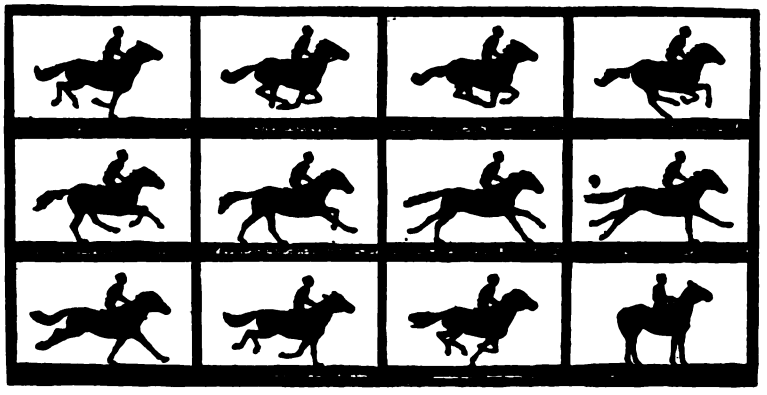


FIG. 114.—STUDIES OF A HORSE BY MUYBRIDGE.

Fig. 118 shows a sea-horse (*Hippocampus*). The principal propelling agent is the back fin, and its motion is so rapid that it cannot be followed with the eye. Twenty exposures per second show us that the motion is undulating and that the undulations take place from beneath upward.

FIG. 115.—FLIGHT OF A HERON. †

* From "Le Mouvement," par E. Marey. † *Ibid.*

It is easy to follow the phases, the pictures being more numerous and on a somewhat larger scale.

Fig. 119 shows a *Comatula*, a species of star-fish. Ordinarily it remains at the bottom of the aquarium and exhibits hardly any motion with its long arms.

When touched with a stick, however, it begins, after an instant, to move in a very peculiar fashion. The ten arms are moved alternately, five of them are drawn up and the five others are stuck down. The feathery filaments on the arms which are drawn up are not visible, as they lie flat against them; those on the other arms, however, are spread out as if seeking a support. This is not shown in the figure owing to its small scale.

If we examine these pictures made by chronophotography we notice that they present a very diffferent appearance from the object in motion itself. By a method of synthesis we can bring these pictures again before the eye in rapid succession and see the object apparently assume life-like motion. The principle was discovered by Plateau early in the present century, and to his apparatus he gave the name of "Phenakistoscope." It is shown in Fig. 120. As each slit passes in front of the eye it reveals a different picture, and if the images are representations of the successive positions assumed by an object in motion the impression is that of a continuous movement. Under the names zoetrope, wheel of life, praxinoscope, etc., various arrangements, embodying the same principle, have been constructed. Previous to the advances made in chronophotography the pictures were drawn by hand, but photography has enabled us to secure far more accurate and instructive results. Fig. 125 represents an instrument devised by M. Demeny. The images are brought before the eye in rapid succession or they can be enlarged by projection on a screen. This arrangement was especially designed for giving the illusions of the motions of the lips, and so successful were the results that deaf mutes were able to read photographed phrases. Edison's kinetoscope is arranged on the same principle. A number of images are made upon a band of celluloid film. From the negatives thus obtained positives are made upon another band of film, and these are made to travel in front of the eye, each image being lighted up separately by an electric spark. In Edison's apparatus, however, only one person can view the image thus shown.

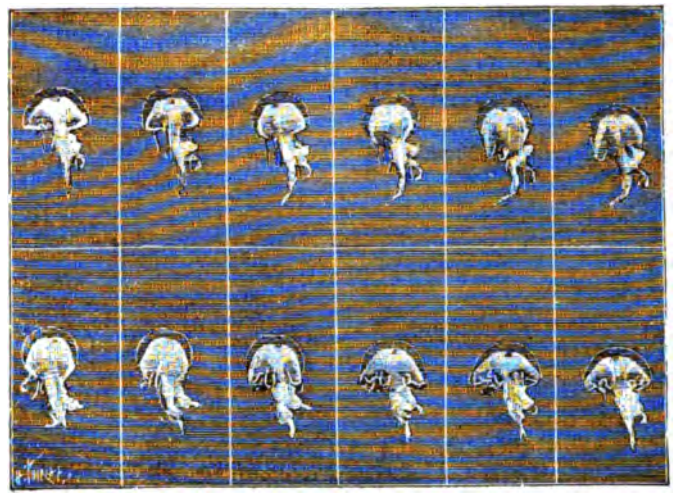


FIG. 116.—MOVEMENT OF THE BELL OF A MEDUSA. THE SERIES BEGINS ABOVE AT THE LEFT AND ENDS BELOW AT THE RIGHT.

FIG. 117.—CHRONO-PHOTOGRAPHS OF A TORTOISE.

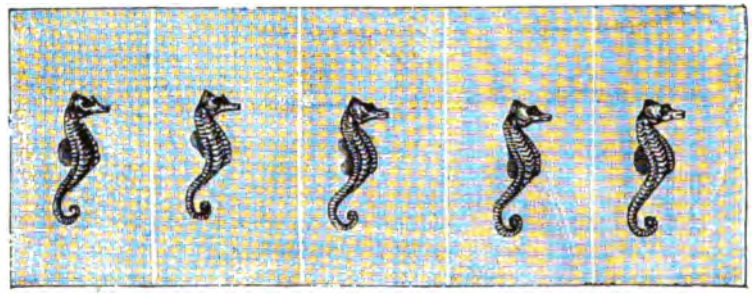


FIG. 118.—SEA HORSE SWIMMING. SERIES FROM LEFT TO RIGHT.

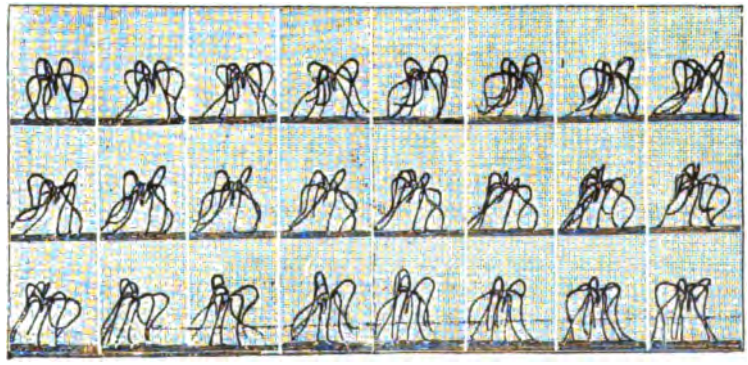


FIG. 119.—MOTIONS OF A COMATULA. SERIES BEGINS AT LEFT ABOVE, ENDS AT THE RIGHT BELOW.

M. Joly has thought to facilitate exhibitions of this kind by making machines that will hold four different images, each of which can be seen by four persons at once.

To attain this result M. Joly has, according to *La Nature*,* arranged the apparatus vertically, and divides it into two parts: the rear, which contains the mechanism (1. Fig. 121), and the front which has the eyepieces.

The celluloid bands on which the pictures are taken are fastened end to end; but in order not to increase indefinitely the length to be unrolled, the same arrangement has been repeated twice, by putting one above the other two identical systems, *C* and *D*, formed each of two bands glued end to end (2). To allow all the images to be seen successively the eyepieces are mounted on a vertical slide and can assume two positions, in which they are either in front of *C* or *D*. This maneuver is performed very simply by working a lever, *A*, from the outside (1), which causes them to rise or fall all four at once.

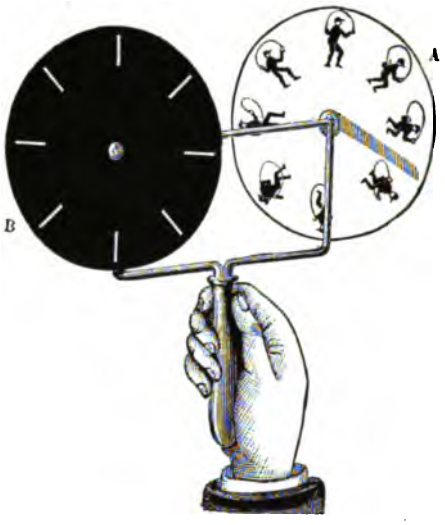


FIG. 120.—PLATEAU'S PHENAKISTOSCOPE.

An electric motor, *M*, controls, by means of a gearing, *E*, one or the other band; the working of the eyepieces by the lever *A* also acts at the same time on a commutator, *G*, that so distributes the current that it is always the band in front of which the eyepiece is that is set in motion.

A very simple special arrangement cuts off the current when half the band has passed (that is to say, when one of the subjects has been exhausted); pressing on a button sets the machine in motion again and permits the other subjects to be seen.

To repeat the same series of operations on the other band the eyepieces must be moved. The bands are mounted on bobbins on which they roll and unroll, while keeping a tension that is given once for all at the moment of mounting by a cylindrical spring, *B*. They pass over a series of cylinders which cause them to take the four positions necessary in order that they should present themselves normally before the axis of each eyepiece. Behind them is a drum, *T*, pierced with longitudinal opening and containing two incandescent lamps, one on the level of each band. This drum acts as the shutter intended to turn on and shut off the light at the intervals necessary to produce the illusion sought; it is so regulated that the passage of the opening over an image coincides exactly with the instant when the latter is found in front of an eyepiece. This arrangement is represented on a larger scale in Fig. 2. It is clear that only one of these two lamps is lighted at a time—the one intended to illuminate the band on whose level the eyepieces are; when the latter are shifted, the commutator *G* so moves that the useless lamp is extinguished and the other lighted.

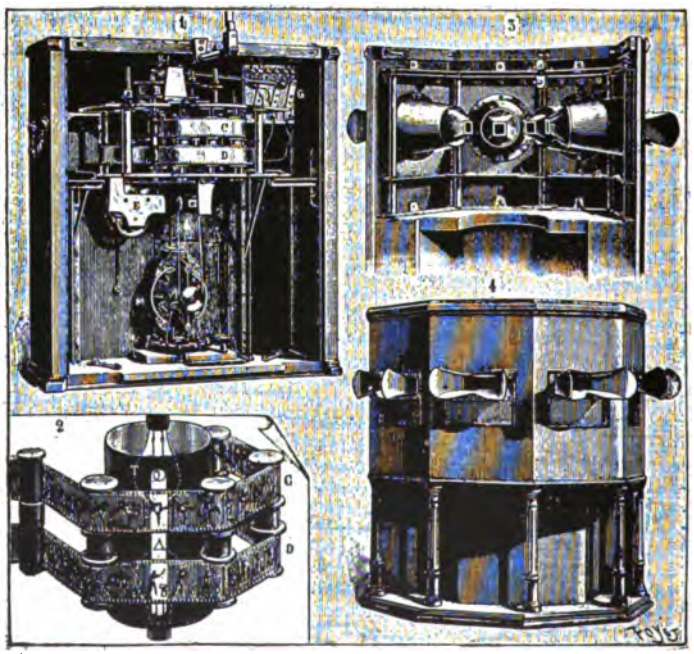


FIG. 121.—MULTIPLE-VIEW KINETOSCOPE.

1, View of the Entire Mechanism. 2, Details of the Shutter and the Bands. 3, Interior Arrangements of the Eyepieces. 4, Outside View of the Machine.

All the manipulation is performed by means of a little arrangement placed behind the case that carries the mechanism, convenient to the hand of the person who is exhibiting the apparatus, and out of the sight of the public; it suffices to move a commutator and then to push a button to cause the first band to unroll and present all its images successively to the four eyepieces; as we have said above, the current is cut off automatically after the first band has passed, and when the button is pressed the motor starts again and moves the second band. This first series having been shown, the eyepieces are lowered to the level of the system *D* and the same series of operations is repeated.

* From translation in *The Literary Digest*.

The bands are the same as those of the kinetoscope, and it is easy to change them. This takes a certain time, but the same subjects can be exhibited during an entire day, and then the exhibitor has time to prepare for the next day by substituting other bands.

Chronophotography has been employed by M. Mach in the study of the growth of plants. The method of M. Mach does not differ materially from that of M. Marey. It is thus described :* "In both cases the course is to take a certain number of images of the same object under identical conditions of light, and of presenting them to the eye, so as to obtain a continuous phenomenon by utilizing the persistence of luminous impressions upon the retina. The first attempt made by M. Mach gave him excellent results. To render the task as little tedious as possible, he selected a rapid-growing plant, a gourd (*Cucurbita pepo*), which he photographed twice a day (7 A.M. and 7 P.M.). From June 28th to August 15th, he obtained ninety-five proofs, reproducing as many different stages of the plant's growth. His arrangements for maintaining identical conditions during the whole course of his experiments were as follows : The vase, containing the seed just beginning to germinate, was placed on a firm stand before a background of solid color; an arc-lamp placed above supplied the necessary light. On commencing the experiments, the blinds were drawn to render the place perfectly dark, and to give full effect to the electric light. The time of exposure depended on the intensity of the light; but being once determined, was adhered to, without variation, through the whole course of the experiments.

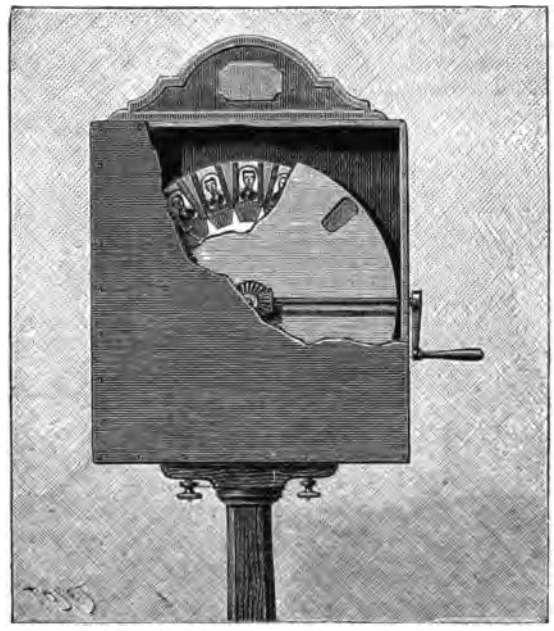


FIG. 122.—DEMENY'S PHOTOSCOPE.

"The reproduction of the phenomena by the aid of a series of successive proofs presented no difficulty. M. Mach was not dealing simply with a single movement resolved into several figures, but with a succession of complex movements recorded in a great number of images; therefore, he was led to construct a special instrument which would admit of the examination of a considerable number of proofs without interruption. His apparatus consists essentially of a metallic drum mounted on a screw-axis, similar to a registering cylinder. For the reception of the positive proofs the stroboscopic drum is pierced with oval openings 15 mm. high and 13 mm. wide. These openings are closed by the photocopies drawn upon thin pellicles of celluloid, and placed in their chronological order. The result is that, when the cylinder is set in revolution, all the images are presented successively at the same point in space, which renders possible their rapid succession before the eye of the observer, either directly or by projection on a luminous screen.

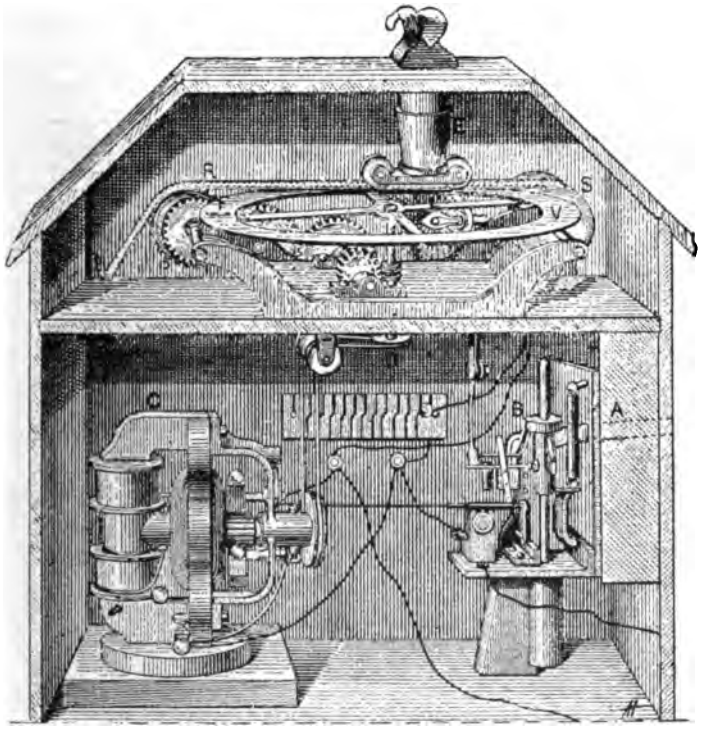


FIG. 123.—INTERIOR OF THE KINETOSCOPE.

"In this apparatus of M. Mach, the revolution of the drum is not continuous but intermittent: each image arrives rapidly within the luminous cone of the sciopticon, where it remains immovable for the fraction of a second, then continues its course, disappearing as suddenly as it arrived. The fixity of the object during the short period of observation is necessary to obtain a perfect

* From *Cosmos*, translated in *The Literary Digest*.

reproduction of the movements. To realize this succession of advancing movements alternating with short pauses, M. Mach employs an ingenious arrangement which we have not space to describe in detail, but which may be understood by the aid of the illustration (Fig. 127).

"By the aid of this apparatus one is able to throw, approximately, ninety-five proofs upon the screen in the course of fifteen seconds.

"The spectator witnesses a very curious scene: he sees the plant grow before his eyes and is able to follow all its transformations. Apart from the phenomenon of growth proper, one observes, too, the phenomenon of heliotropism, that is, the turning of the leaves toward the light—the movement of the leaves, etc.

"The development, at first very rapid, is progressively retarded, a period of great activity succeeding one of relative repose. At this moment, the flowers appear. We see them expand and wither. The plant itself is subject to the same laws. We see the cotyledons rise from the seed, to be followed by leaf, flower, and fruit, and lo! the plant withers before our eyes, the whole process of birth, growth, flowering, fruiting, and decay, occupying a space that may be counted by seconds."

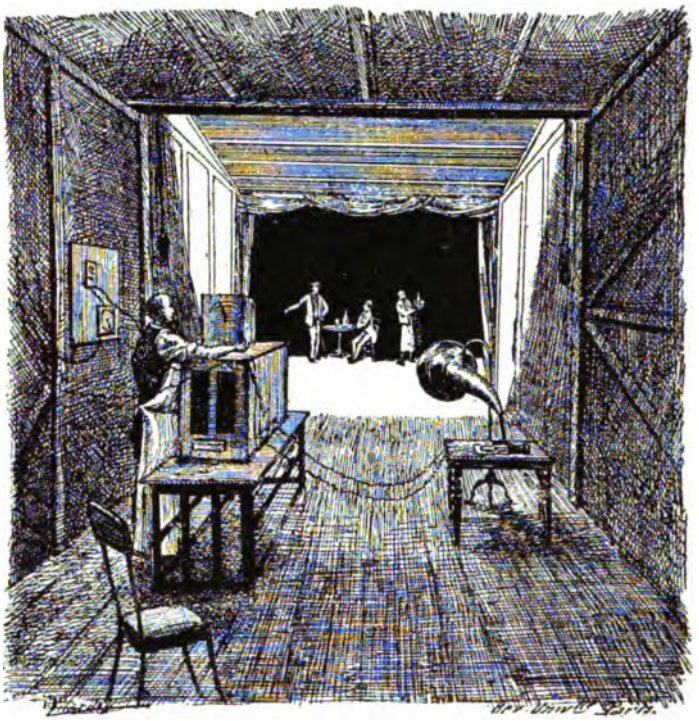


FIG. 124.—INTERIOR OF THE KINETOGRAPHIC THEATRE.

CHRYSOTYPE.—One of Sir John Herschell's processes. A sheet of paper was immersed in a moderately strong solution of ammonio-citrate of iron and dried in the dark. The paper is then exposed to the light under the negative until a very faint impression is obtained. The

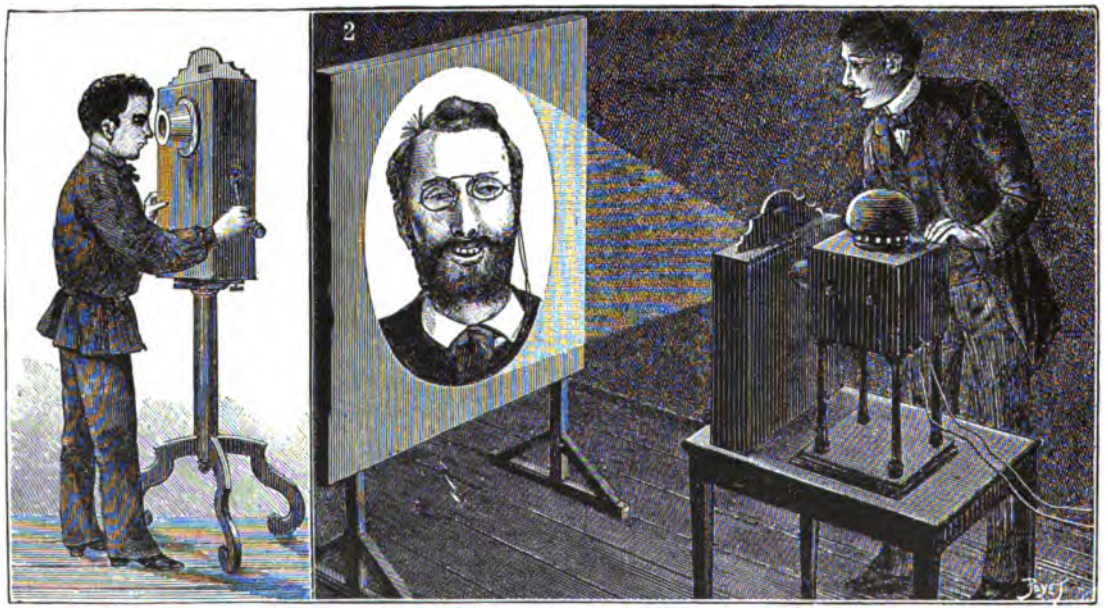


FIG. 125.—NO. 1, DEAF MUTE READING FROM SPEAKING PHOTOGRAPHS IN THE PHOTOSCOPE. NO. 2, PROJECTION OF SPEAKING PHOTOGRAPHS BY MEANS OF AN OXYHYDROGEN LAMP.

development took place by brushing over the exposed paper a neutral solution of gold of such strength as to appear the color of sherry. The print then turns to a purple tint, and is washed in several changes of water, and fixed in a weak solution of iodide of potassium, washed again, and dried.

CHRYSTALLOTYPE.—A name given to a kind of picture printed upon a translucent material.

CIRCLE OF ABERRATION.—See **Aberration.**

CITRATE OF AMMONIUM.—See **Ammonium Citrate.**

CITRATE, TEST OF.—With silver nitrate a white precipitate is formed which does not blacken when boiled.

CITRIC ACID (Formula, $C_6H_8O_7 + H_2O$; molecular weight, 210).—An acid which occurs in lemons, oranges, cranberries, and also with malic acid in gooseberries, whortleberries, raspberries, etc. It also occurs in many plants and roots. It is obtained by allowing the juice to undergo an incipient fermentation, filtered, and neutralized by boiling with chalk and lime. The precipitated calcium citrate is then decomposed by an equivalent quantity of sulphuric acid.

Citric acid is a tetratomic tribasic acid, usually crystallizing in a white transparent form, soluble in water, and having an acid taste. Citric acid is frequently adulterated. The presence of sulphuric acid can be detected by adding a large excess of hydrochloric acid, followed by barium chloride. A white precipitate will occur. To detect tartaric acid, take a strong solution and mix it with an excess of caustic soda and permanganate of potassium sufficient to color a light pink. If the mixture be boiled it will become brown should tartaric acid be present.

It acts as a powerful restrainer of the action of the developer. It is also useful in keeping the shadows clear when intensifying a negative. Mixed with sulphate of iron it becomes useful in clearing yellow stains from negatives. In positive printing it is largely used. If added to the nitrate solution for sensitizing it assists in the preservation of the paper, and also in giving more brilliancy to the tone. In gelatino-chloride of silver positive paper large quantities are added, and it assists in keeping the paper in good condition for many months.

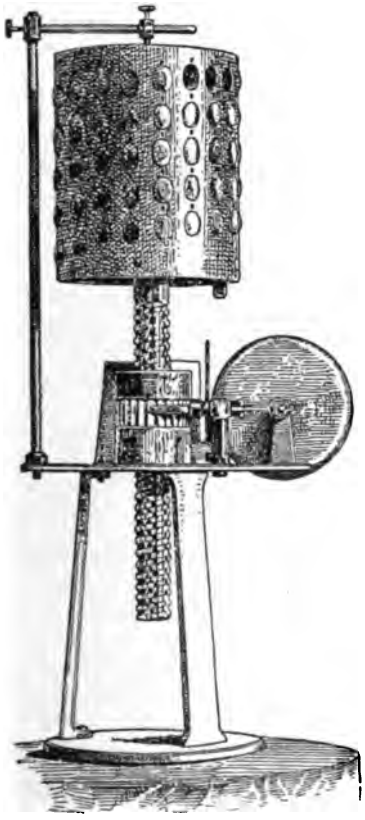


FIG. 127 —M. MACH'S APPARATUS.

Photographed by W. K. L. Dickson.

FIG. 126.—KINETOSCOPE PICTURES OF SANDOW.

CLEANING.—Cleanliness is perhaps more essential in photographic operations than in anything else. Cleaning is an art only arrived at by practice. A skillful operator will clean a glass in a few seconds, while another, unused to the art, will not have produced a chemically clean piece of glass in as many hours.

Cleaning Glass.—There are many methods of cleaning a glass plate successfully. The application of Tripoli powder solution, rubbed well over the surfaces with a piece of old rag, is one to be recommended. This is then removed and a final polish given to the surface with a dry piece of chamois leather or an old silk handkerchief, which should be well washed in carbonate of soda and water, and well dried before use.

A brand of soap known as "Monkey soap," and used only in cleaning non-destructible articles, is an invaluable cleanser of glass plates, as it seems to entirely remove all grease and other foreign matters.

In polishing a glass plate positive electricity is generated on it, and negative on the rubber. This will often produce an evil effect upon the subsequent operations; for instance, if the glass is to be coated with collodion the electricity will prevent its proper adhesion, and it is therefore necessary to dispel the latter by passing the handkerchief gently and slowly over the surface to allow the two electricities to combine.

There are various methods of testing if glass be clean. The simplest is, perhaps, by breathing gently, and observing if the condensed breath leaves the plate regularly and evenly.

Glass which is exceptionally dirty should be immersed in a ten per cent. aqueous solution of nitric acid, then washed and rubbed over with a solution of caustic potash or soda half an ounce, and methylated spirit half an ounce, added to four or five ounces of water, or scoured well with the soap already recommended.

Grease.— Greasy glasses or vessels must not be washed until the grease is removed with a dry cloth (only used for that purpose), and the glass or vessel washed in a ten per cent. solution of nitric acid. It is then washed and treated as described above.

Collodion can easily be removed from bottles by allowing the ether and alcohol to evaporate, filling the bottle with cold water and using a bottle brush. Dry and rinse out with alcohol.

Albumen being soluble in alkaline solutions can be removed by applying a solution of caustic potash, and washing well with water.

Old Films.—Old or spoilt gelatine negatives should be soaked in a solution of chromic acid, or in a warm solution of common soda. This will decompose the gelatine, and the films may be detached and the glasses washed. Another method is to soak in a weak bath of hydrochloric acid, and thoroughly wash and dry.

Old collodion films can be removed by immersion in

Nitric acid	1 ounce
Water	10 ounces

Varnished Negatives.—In the case of negatives which have been varnished, the varnish must first of all be removed by soaking the plate in strong spirits of benzine, and removing the soluble varnish with a piece of flannel or tuft of cotton wool.

CLEARING SOLUTION.—Term applied to a solution having a weak dissolving action upon metallic silver. For collodion work a solution of potassium cyanide, 30 grains to the ounce, or a solution of zinc chloride, 10 grains to the ounce is employed. In the gelatino-bromide process the following clearing baths are used:

No. 1.—	Alum	2 ounces
	Citric acid	1 ounce
	Water	10 ounces
No. 2.—	Ferric chloride	50 grains
	Potassium bromide	30 grains
	Water	4 ounces
No. 3.—	Potassium iodide	1 ounce
	Water	2 ounces
No. 4.—	Alum	1 ounce
	Citric acid	1 ounce
	Ferrous sulphate	3 ounces
	Water	20 ounces

CLICHÉ.—A French term for a stereotype used in this country for the same meaning. It is also applied to the negative and to photographic printing blocks.

CLIP.—A little clasp made of wood for hanging paper up to dry.

CLOUD NEGATIVES.—Except with instantaneous exposures it is rare that the clouds are included in landscape or architectural negatives. Separate negatives are made, and what is termed "double" or "combination" printing is carried out. For the manufacture of cloud negatives no special apparatus is required. They can also be purchased in large quantities, being manufactured chiefly by photographers stationed at the seacoast, where the cloud effects are usually finer; but whether it is correct to use these for any other than seascapes is a doubtful point. For convenience in printing, cloud negatives are usually made upon films or paper.

The former are superior to the latter, as they do not require oiling to render transparent. For making cloud negatives use a slow plate or film. Orthochromatic plates or films are the best for this purpose. In some cases by the use of a yellow screen a far finer effect is obtained. Dr. Neuhauss, in *Die Rundschau*, recommends the use of plates orthochromatized with erythrosin. A solution is made of 0.1 gramme of erythrosin in 95 c.c of alcohol of a strength of 95 per cent. A bath for use is made up of 2.5 c.c. of this stock solution in 100 c.c. of water and the solution filtered. In this the plates are immersed for from 60 to 70 seconds, keeping the solution in motion the whole time. They are then drained on blotting paper and dried. A still better effect is said to be obtained by the additional use of a liquid light filter. A glass trough made by cementing two pieces of glass with absolutely plane and parallel sides at a short distance apart. The trough thus formed is filled with a solution composed of sulphite of copper 44 grammes, bichromate of potash 2.25 grammes, sulphuric acid 0.5 c.c. and 250 c.c. of water. Rapid exposures should be given, with a small stop, and a fairly restrained developer used. The development should not be carried out too far, for if made too dense the negative will cause considerable trouble in printing.

FIG. 128.—CLIP.

It will, perhaps, be unnecessary to point out that in photographing clouds only those should be chosen which are likely to be useful and suited to the pictures taken. Some very fine stormy cloud effects are often visible in rough weather; but these are of little use, as photographs are rarely made in this kind of weather, and to print stormy clouds on a mild landscape would be ridiculous in the extreme. The position of the sun must also be noted, and it is as well to make a little collection on a good day of clouds taken at different intervals during the day, to be used for differently lighted pictures, for it would never do to use a negative of clouds lighted from the left for a landscape lighted from the right.

Some very fine cloud photographs have heen made by Mr. A. G. Henry, of the Weather Bureau, at Washington. He employs a screen formed of a saturated solution of bichromate of potash inclosed in a plate-glass cell having parallel sides. The construction of this cell is shown in Fig. 129, in which *a a* are squares of plate glass, and *b* is a ring cut from a glass tube and ground to render its edges parallel and smooth.* One side of the ring is perforated and furnished with a stopper. The ring is cemented between the two glass plates with balsam of fir or other suitable cement. The saturated solution of bichromate of potash is introduced through the perforation, and the cell thus made is inserted in a piece of cork, *c*, which fits over the collar of the camera lens. The proper thickness for the cell is shown in the engraving. The deanele will of course vary with the size and angle of the lens.

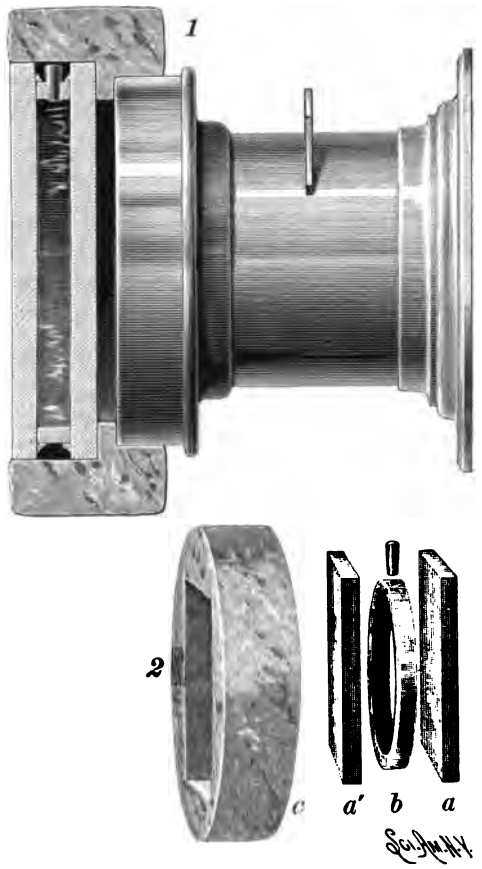


FIG. 129.—BICHROMATE CELL FITTED TO LENS.

The naked eye can rarely see the real cloud effects, the light being too actinic. We would recommend the photographer carrying with him a small piece of smoked or dark colored glass with which to view them.

Experiments in cloud photography made recently by the London Meteorological Society proved the best effects to be obtained not by photographing the clouds direct, but their reflection in a black mirror. These mirrors are known as "Claude Loraine" mirrors and are made by polishing a piece of jet black glass with a perfectly plane surface. We have tried using a piece of plate glass backed with a black substance, but it is difficult to overcome the double reflection obtained from the surface of the glass and the backing compound. In using the black glass mirror it is placed at the polarizing angle and a photograph made of the reflection. The difference between the effect thus obtained and the result of direct photography is remarkably striking.

CLOUD PRINTING.—Almost all landscapes are

*We are indebted to the kindness of the publishers of the *Scientific American* for the loan of cut illustrating the apparatus.

improved by the addition of suitable cloud effects, although it often happens that one obtains pictures which have a pale grey sky, and this may be shaded off in printing to give a more artistic effect than clouds. The following instructions for "printing-in" clouds is taken from Burton and Pringle's "Processes of Pure Photography": If the original sky of the view negative prints any degree beyond a pale grey, the sky will require to be blocked out with opaque paint of some kind. A pale grey horizon over a landscape is better than a hard chalky white for our purpose, but anything darker than pale grey will require blocking out. If the grey is a shade darker than it ought to be, a cloud negative presenting considerable contrast may be chosen, provided it is otherwise suitable. As a rule, a very chalky sky means an under-exposed negative.

The blocking out may be done on the face of the negative with a solution as thick as possible of vermilion water color paint, or Indian ink.

Opaque material is sold for this and similar purposes. So long as the landscape horizon presents a sharp line, there is no difficulty for a steady hand; but if tree branches project into the sky the operation becomes more difficult. Branches are best blocked out, not by straight lines, but by "dabs," or stippling on the back of the negative. Practice alone will teach this. Very intricate architectural lines are often puzzling, but care and practice will enable us to block them out perfectly.

The landscape being printed by a printing-out process, and visible as in the albumen process, or partially visible as in the platinotype process, a suitable cloud negative is selected and placed face to face in a suitable position with the landscape print, which has the white sky, or nearly so. The two are then laid in a printing frame together, with the cloud negative uppermost, and the frame is then closed in the usual way. If the cloud negative be not too dense, or the landscape sky not too dark, the shape of the cloud will be distinctly seen from the front of the frame, and the horizon line of the landscape will be clearly recognized. The frame is laid face up in the usual way for printing, and the landscape entirely covered with a *limp* opaque cloth, as velvet. When the horizon of the landscape is a sharp line, as of hills, the difficulty is slight; where the outline is jagged the operation requires more skill. To avoid a hard line the upper edge of the velvet must be constantly moved if the printing is done in sunlight, frequently if in diffused light. The cloud picture is to be graduated or vignetted down to the landscape. Where there is a dark mass already printed against the sky, as in the case of heavy foliage, this may be practically disregarded, as that part being already dark, any clouds in the negative coming over it cannot naturally be printed, the paper being already printed in those parts. Thus where dark tree branches come against the sky the cloud may in most cases be printed right over the branches, and if this is well done the result is very natural and satisfactory.

Cloud negatives upon paper or films may be printed from either side. The paper negatives should be kept between sheets of oiled paper, otherwise they will lose their transparency.

CLOUD SHUTTER.—A shutter so constructed that it gives a much shorter exposure to the sky than to the foreground of the picture. By this means the images of clouds are secured.

COAGULATE.—To clot or curd. When a liquid coagulates it changes to a semi-solid state without evaporation and without crystallization. Thus it differs from congestion for the reason that it is not attended with a fall in the temperature of the substance coagulated.

COAGULUM.—A coagulated or concreted mass.

COAL NAPTHA.—See **Naptha.**

COAL TAR.—A tar produced in the destructive distillation of bitumenous coal, and from which many of the aniline colors—napthalene, phenol, etc.—are prepared.

COATING.—The term is largely used in photography to define the act of covering glass, paper, etc., with a film of any kind. In the dry-plate process the glass is coated with a gelatine emulsion (this is described under **Dry Plates**) and the paper is coated with a layer of albumen or gelatine. The simplest method of coating glass is to pour the necessary quantity of the solution on to the top right-hand corner of the glass, and by moving the glass in different slanting directions cause the solution to run to the top left-hand corner, and from there to the bottom left-hand, and finally to the lower right-hand corner, from whence the superfluous solution can, if necessary, be poured off into the bottle, or if the whole quantity of the solution is required to be kept on the glass the latter is, after coating, placed on a level stand. In coating glass with gelatine it should be warmed to about the same heat as the solution. Instructions for covering glass with collodion will be found in the description of the collodion process.

The coating of paper is a very simple matter if properly carried out. In coating with collodion the paper should be laid upon a sheet of glass, and the edges turned up all around. It will then be an easy matter to coat in the same manner as with glass. Another method is to place the paper between two suitable frames hinged together, which serve to hold the paper and stretch it tight. The simplest method of coating paper with gelatine is to place the solution in a dish, and draw two pieces of paper placed back to back through it. The pressure of the liquid keeps the two papers together, and there is no fear of the solution getting in between. A thin

coating may be obtained by passing the paper slowly through the emulsion, and a thick film by drawing rapidly. Another way is to float the paper face downwards upon the solution placed in a flat-bottomed dish. With this method the formation of bubbles is extensive, and they should be carefully taken out with a camel-hair brush dipped in the solution, and the paper replaced into position upon the emulsion. Another method of coating paper with gelatine is to first coat a glass, previously rubbed with chalk, with the emulsion, and lay the sheet of paper over it. The gelatine adheres to the paper when dry, and leaves the glass with a very high polish. Various methods of coating paper will be found under **Collodio and Gelatino Chloride Printing and Processes.**

COATING MACHINE.—A machine for coating plates or paper. In some machines silver or glass roller revolves rapidly in a trough filled with the emulsion. In revolving the roller carries with it a thin film of the emulsion, which is removed with the scraper and conducted to the sheets of glass passing one after another beneath. In other machines the emulsion is pumped up and flows with an even flow on to the glass plates. See **Dry Plates.** A German method of coating glass is based upon the principle of centrifugal force. A sheet of glass is clamped to a revolving plate, and revolves with it horizontally. A small quantity of the emulsion is placed in the centre and the plate set rolling. This action spreads the emulsion evenly over the plate.

CO-AXIAL.—Having a common axis.

COBALT (Symbol, **Co**; atomic weight, 58.7).—Cobalt occurs in a free state only in meteorites, and combined with arsenic and sulphur. It is a white or slightly reddish metal, having properties very similar to iron.

COBALT BLUE is prepared by precipitating a solution of a cobalt salt with potassium or sodium phosphate. The violet precipitate formed is then washed and mixed with four to five equal parts of freshly precipitated alumina. It is then dried and calcined at a cherry heat for half an hour or so in a clay crucible. Prepared in this manner it is one of the most permanent blue pigments.

COBALT CHLORIDE.—Cobalt chloride has been recommended for toning silver prints to obtain a reddish color. The formula given is:

A.

Water	1000 c.c.
Cobalt chloride	10 grammes

B.

Water	1000 c.c.
Calcium acetate	40 grammes

To tone, equal parts of A and B are taken, mixed together, and allowed to stand three or four days. The solution is then filtered and rendered absolutely neutral by the addition of hydrochloric acid or bicarbonate of soda whichever is necessary. Fix in hypo as usual.

COBALT SALTS.—The soluble salts of cobalt are prepared by solution of the metal and hydrates in the various acids. They form pink solutions when diluted, but if concentrated or dried they are blue. This property has been made use of in the manufacture of sympathetic inks and barometers. A weak solution of nitrate of cobalt brushed on to a piece of white paper gives a pink surface, which if warmed turns blue. The chameleon barometer, invented by the late W. B. Woodbury, was based upon this fact, the cobalt changing with the heat or amount of dryness in the atmosphere. If one writes with a very dilute solution of nitrate of cobalt, the writing when dry will be invisible, but if the paper be heated before a fire the letter will be distinctly visible and of a bright blue color.

COCKLING.—Prints may be prevented from cockling by adding a little glycerine to the last water when washing.

COFFEE PRESERVATIVE.—A preservative used in the dry collodion process. It is made up as follows, and carefully filtered:

Coffee sol. (grouud)	2 ounces
Boiling water	10 ounces

COFFEE PROCESS.—A number of modifications have been made of this process, the best being perhaps that of M. de Constant. Abney's description of this process is as follows:

The collodion to be recommended for this process, according to M. de Constant, is ordinary collodion, with the addition of two grains of cadmium bromide to the ounce. If collodion be home-made the pyroxyline should be manufactured at a high temperature in the acids (see **Pyroxyline**), and may be known in commerce by its yellow appearance, and by being found to separate in short rather fibrous particles. The plate is given a substratum (see **Collodion Process**), it is then coated, and the film sensitized by placing in the silver bath for seven minutes

in summer and ten in winter to convert the greater part of the bromide into the silver salt. It is then well washed.

The preservative is formed as follows:

SOLUTION 1.

Distilled water (boiling)	5½ ounces
Mocha coffee (ground)	½ ounce
White sugar	90 grains

SOLUTION 2.

Distilled water	5½ ounces
Gum-arabic (powdered)	90 grains
Sugar candy (powdered)	20 grains

Solution No. 1 is allowed to cool in a well corked bottle. Both solutions should then be filtered and mixed.

Two applications of the preservative are necessary by immersing in a flat dish. The plate is then placed on end to dry upon blotting-paper to drain off the superfluous solution. It is then transferred to the drying box, and when dry the surface of the film should possess great brilliancy, and be free from fog or stains when viewed by transmitted light. If a cloudy aspect appears on parts of the film a heated flat-iron passed over it an inch or so from the surface will restore its brilliancy.

According to M. Constant the exposure required is about three or four times that necessary for wet plates.

In developing the plates should be placed in rain water for three or four minutes. They are then flooded over with

Sat. sol. ammonium carbonate*	8 drops
Water	4 drachms

This quantity is sufficient for a whole plate. This is worked over the plate until the image begins to appear, and until there is no further action caused by it. The solution is then returned into the developing cup, in which has been previously dropped one or two drops of

Pyrogallic acid	60 grains
Alcohol	1 ounce

The solution with this addition is again flooded over the plate as quickly as possible, its action being very rapid. The image now appears fully by reflected light, but hardly at all by transmitted light. When all detail in the shadow is brought out the image is intensified with

Pyrogallic acid	2 grains
Citric acid	2 to 4 grains
Water	1 ounce

But by this method the image will always appear transparent. To avoid this, M. de Constant recommended the following before the final pyrogallic intensification:

Ammonia sulphate of iron	45 grains
Copper sulphate	45 grains
Citric acid	45 grains
Water	3½ ounces

Two or three drops of a 20-grain solution of silver nitrate can be added after the first application. On the second application the negative becomes of a color resembling that of a wet plate. The ordinary intensifier should be used after this. If the negative shows a tendency to become solarized, it should be fixed immediately, and the intensification done after fixing. These plates may also be developed with the ferrous oxalate or the alkaline developer. For fixing use hyposulphite of soda or a weak solution of potassium cyanide, with the addition of a few drops of acetic acid to prevent blistering.

COHESION.—The act of adhering or joining together. In chemistry, the force which unites two molecules of the same kind; strong in solids, weak in liquids.

COLD.—It was formerly believed that cold was an entity, and that it could be reflected from polished surfaces like heat and light. This, however, is not the case. Cold is simply an absence of heat. It is essentially a relative term. Ice may be considered a hot substance when compared with frozen mercury, and a very hot substance when compared with solid carbonic acid. If we take three vessels, and pour hot water into the first, cold water into the second, and water of intermediate temperature into the third, and place one hand into the hot water and the other into the cold, we shall find on now placing both hands in the water of intermediate tem-

* "One drop of concentrated liquor ammonia may be substituted."—ABNEY.

perature it will feel hot to the hand which has been in the cold water, and cold to the hand which was placed in the hot water; thus water at the same temperature may appear both hot and cold. Absolute cold would be the absolue zero of temperature, at which point matter would possess no heat at all. A substance is relatively cold when it possesses less of the motion called heat than the substance it is compared with. A hot substance—a red-hot suspended ball of metal, for instance—gets colder and colder, because it radiates its heat into space; it loses molecular motion, and the more motion it loses the colder it is said to be. When it cools down to a temperature below that of our bodies, we call it cold to the touch, because it possesses less of the motion of heat than our nerves and abstracts heat from them, and this withdrawal of motion of the nerves produces the sensation cold. (Rodwell's Dict. Sci.)

COLD BATH PROCESS.—See **Platinotype Process.**

COLD EMULSIFICATION.—A method of giving sensitiveness to a gelatine emulsion without the application of heat. See **Emulsion.**

COLD TONE.—A term often used to distinguish the tone of a photograph having a color without warmth.

COLLIQUATE.—To melt; to change from a solid to a liquid.

COLLOCINE.—A colloidal restrainer introduced by Carey Lea, and used in the iron development for wet-plate negatives. The solntion being of a syrupy nature offers considerable resistance to the solid particles traveling through it.

It is prepared by softening one ounce of French glue in a mixture of one and a half ounces of water and one drachm of sulphuric acid. When softened the water is boiled to dissolve the glue. Half an ounce of distilled water is then added, and the water boiled for a further period of two hours. Next eighty grains of granulated zinc are added, and the boiling continued for one and a half hours. The solution is then allowed to settle, and the clear fluid decanted off. One minim of this solution is added to every three ounces of a fifteen grain solution of iron.

COLLODINE (Formula $C_8H_{11}N$).—An alkaloid obtained chiefly by the distillation of bituminous shale. It is a colorless aromatic smelling oil, a powerful base, and gives white fumes if a rod dipped in strong hydrochloric acid be held over it. It boils at 180 degs., is insoluble in water, but soluble in alcohol, ether, and different oils.

COLLODIO-BROMIDE EMULSION.—See **Collodion Emulsion.**

COLLODIO-BROMO-CHLORIDE EMULSION.—An emulsion which contains both a bromide and a chloride in its compostion. A very good emulsion of this kind can be made by mixing two parts of the unwashed collodio-bromide emulsion with one part of an unwashed collodio-chloride emulsion, the formulæ for both of which will be found elsewhere. By altering and otherwise regulating the proportions of these two emulsions very varied effects can be obtained.

COLLODIO-CHLORIDE EMULSION.—In this a chloride is substituted for the bromide usually used in the manufacture of collodion emulsions. It must be pointed out that there are two kinds of collodio-chloride emulsions used for different purposes—the one in which the image is developed, and the other in which it is printed out in the same manner as albumenised paper. The latter is called a collodio-chloride printing-out process and is described under that heading.

The formula for making a collodio-chloride emulsion is thus given by Abney:

Pyroxyline	15 grains
Calcium chloride	20 grains
Silver nitrate	50 grains

The calcium chloride is first dissolved in half an ounce of alcohol .805 by warming it in a test tube. Five grains of the pyroxyline are then placed in a two-ounce bottle, and the alcohol containing the calcium poured on to it. After a few minutes the addition of half an ounce of ether should be made, when the cotton will soon dissolve.

In another test tube dissolve fifty grains of nitrate of silver with the smallest quantity of water capable of dissolving it. Then add one ounce of alcohol heated to boiling point, and mix. While the silver was dissolving in the test tube the remaining ten grains of the pyroxyline should have been put into a four-ounce bottle, and the alcohol and silver solution poured on to it. Now add one ounce of ether, gradually shaking the solution the while. We have now two collodions—the one containing the calcium chloride, and the other the nitrate of silver. The two are taken to the dark room, and the calcium chloride collodion is very gradually added to the other, stirring the whole of the time. We have now a silver chloride emulsion with an excess of haloid. A trial plate should be coated, half of it exposed to the light, and the whole placed in a ferrous citrate developer. Only that part which has been exposed to the light should blacken with the action of the developer. If, however, the unexposed portion shows signs of fog, three or four drops of a

twenty-grain solution of cupric copper in alcohol should be added to the emulsion. (Abney.) The emulsion can be washed before coating the plates; but this is not really necessary.

Glass plates are cleaned, polished, coated with a substratum, then with the emulsion, and afterwards flooded over with the preservative:

Beer	6 ounces.
Sugar	1 drachm.
Pyrogallic acid	6 grains.

After exposure, the plates are rinsed in water and developed with the ferrous-citro-oxalate developer, and if a warmer tint is required they can be afterwards toned in

Uranium nitrate	10 grains.
Potassium ferricyanide	10 grains.
Water	12 ounces.

Upon immersion in this toning bath the tint will gradually become warmer, and if kept in long enough will assume a very agreeable cholocate tint.

This process is admirably suited for transparencies and used for collodion transfers. Many other develepers may be used.

COLLODIO-CHLORIDE PRINTING-OUT PROCESS.—A silver printing process in which collodion is used as the article to hold the silver salts. The name aristotype has also been applied to this process as well as to its sister process, the gelatino-chloride. It is also termed collodion paper.

The earliest experiments in collodio chloride printing were made as far back as 1864 by G. Wharton Simpson.* This gentleman attended a lecture given by Professor Roscoe, in which the latter stated that the action of light on chloride of silver paper was a reliable means of obtaining photometric measurements. Simpson declined to agree with this theory, and to prove the correctness of his objection instituted a series of experiments, using different media for holding the sensitive salts, as he contended, and rightly, that there would be a considerable change due to the proportion and character of the organic matter in this or the paper. The result of these experiments was the discovery of the collodio-chloride positive printing process, which was first published and a paper read before the London Photographic Society on March 14, 1865. In this paper Mr. Simpson claimed for this process many advantages over albumen. "First, the sensitive salts are all combined in one inert vehicle, no changing conditions exist; every specific portion of the vehicle used contains definite proportions of the salts, and the stock from which it is used is not impoverished or changed in any respect. There is no interchange of parts going forward at each step of the process as with sensitizing albumen paper. The last sheet coated from a bottle ot the preparation contains on its surface the sensitive salts mixed in the same proportions as the first. There is nothing to prevent absolute uniformity of results."

Simpson's communication of his process to the Photographic Society was received with unbounded enthusiasm, but notwithstanding this the collodion process never seems to have been taken up except by one or two experimenters.† It apparently died a natural death, or perhaps we should say went into a kind of trance, for it was not until years after that it was revived.

W. Terry, an American, added the fulminating compounds of silver to the emulsion. The addition of a few drops of the supernatent solution of strong ammonio-nitrate of silver, or oxide of silver dissolved in nitrate of ammonia to which alcohol was then added and heated to the boiling point, to even a bad emulsion of collodion chloride, had, Terry stated, been found to impart wonderful properties of fine color and brilliance.

A number of experiments were then made by different workers with the various chlorides more or less soluble in alcohol. Among these were those of cadmium, ammonium, barium, calcium, cobalt, sodium, strontium, lithium, magnesium, and zinc.

About the year 1884 Liesegang produced a fine collodion emulsion for printing on paper, glass, etc. To the process he gave the name Aristotype—a name that seems to have adhered to it, although it has become rather confusing since the same title was given to the gelatino-chloride process.

There is no country in the world, however, where the collodio-chloride of silver process is as popular as in America. In this country the manufacture of the paper has been taken up by several firms on a large scale and backed by considerable capital. All difficulties seem to have been surmounted and the paper turned out nearly perfect in every respect.

The difficulty with the curling caused by the expansion of the paper support appears to have been almost entirely surmounted.

The collodion papers of commerce are prepared chiefly upon the enamel or baryta paper, which serve to keep the sensitive film on the surface and so come into close contact with the negative, reproducing the finest details. Any ordinary white paper can be used provided it is chemically pure. We know of but few papers that answer this important condition. Rive's,

* A French writer, M. Gravier, gives the honor to Dr. Von Monckhoven (1862); according to Traill Taylor, however, the process was originally introduced by M. Gaudin in 1861.

† W. T. Bovey made an important improvement by the addition of an organic acid, by which this system of printing became directly applicable to glass or porcelain.

Saxe's, and Steinbach's are of pure quality and can be used with safety; others must be experimented with.

The first formula was Simpson's, and, although old, it can be made to yield really good pictures. To each ounce of methylated spirit 16 grains of silver nitrate are added by triturating the salt in a mortar, then adding the spirit a little at a time and pouring it off until it is dissolved. A stock solution can be made, and to each ounce of it one ounce of ether is added and the necessary proportion of soluble gun-cotton. The proportion of cotton depends much upon its quality; of some samples six grains to the ounce gives a collodion quite thick enough, and with some other kinds ten or twelve grains to the ounce may be required.

After the collodion is formed the addition of three-quarters of a drachm of a solution of chloride of calcium or alcohol, 16 grains to the ounce is made. This is added a drop at a time, the collodion being shaken between each addition. The sensitive emulsion ready for use is thus formed.

Liesegang's formula is one that has given very satisfactory results in our hands- In a glass measure dissolve 8 grammes of nitrate of silver in 6 c.c. of distilled water, heat being applied. Drop this solution in a bottle containing 135 c.c. of alcohol. In cool weather it is necessary to place the bottle in a vessel containing warm water, add 8 grammes of soluble gun-cotton, and after a good shaking pour in 160 c.c. of ether. Further violent shaking will produce a grayish-white collodion. In another glass dissolve 1 gramme of chloride of lithium in 35 c.c. of alcohol, together with 1 gramme of tartaric acid. This solution is dropped into the argentiferous collodion, which must be kept continually moving. For vigorous negatives take more of the chloride, as softer prints result from doing so. If preserved in a well-corked bottle this collodion will keep any length of time.

Heiderstadt's formula is as follows: 1.5 gramme of chloride of lithium, 1.5 gramme of nitric acid are dissolved by the application of heat in 50 c.c. of alcohol; this solution is added to 500 grammes of ordinary 4 per cent. collodion. 14 grains of acetate of silver are dissolved with the aid of heat in 6.7 grammes of distilled water, then added to 150 c.c. of diluted alcohol, which is heated to ebullition. The argentiferous solution is poured gradually into the chloride solution, and afterwards from 4 tc 6 grains of glycerine solution added.

In the *Deutsche Photo Zeitung*, Herr Vollenbruch published the following process for the preparation of a collodion paper. The emulsion contains the following ingredients:

Strontium chloride.	4 grammes	61.7	grains
Lithium chloride	2 grammes	30.8	grains
Citric acid.	8 grammes	123.4	grains
Glycerine, pure	12–14 c.cm	210	minims
Silver nitrate	28 grammes	432	grains
Ether	100 c.cm	27	fluid drachms
Alcohol	100 c.cm	27	fluid drachms
Collodion 3 per cent. pyroxline	800 c.cm	216	fluid drachms

It is prepared thus:

A. Dissolve the silver in 130 minims of water, then add 13½ drachms of alcohol, and mix it to half the quantity of collodion (108 drachms).

B. Dissolve the strontium and lithium chloride in 1½ drachms of water, add 6¾ drachms of alcohol, and finally mix the whole to the remainder of collodion.

Now mix gradually, in shaking, meanwhile, B to A, and when the emulsion is made, add the ether and the glycerine. Allow it to stand for a few hours, filter and use. This quantity of emulsion is sufficient to coat from thirty to thirty-five sheets of paper 19 x 23 inches.

Preparation of the Emulsion.—There are two ways of preparing the emulsion, one in which plain, ready-made collodion is used and the silver and salts added to it, and the other in which the collodion is made in the same process. We will give them both.

For the first method we require a plain collodion. This can be purchased or prepared by mixing equal parts of ether and alcohol, and adding 2 to 3 per cent. of English pyroxyline. Now the thickness of the collodion is a very important matter. We would recommend a 2 per cent. in the summer and a 3 per cent. in the winter; a thin collodion is always better to work with; it gives an evener film, and if sufficient density is lacking, it is a very simple matter to coat the paper a second time, or it can be allowed to remain longer on the paper before pouring off the superfluous quantity. If, however, a thick collodion is used all manner of evils arise. The film is likely to be thicker in some parts than in others, which would be at once seen in the toning, as the thinner parts would soon become acted upon by the gold bath leaving the thicker portions quite red.

Collodion, like wine, improves by keeping. An old collodion that has been allowed to stand some time is always superior to one freshly made, for the reason that it is more perfectly combined and, all sediment and foreign matter having fallen to the bottom, it is much clearer and cleaner. Therefore, it is advisable to make the collodion some time previous to use. Keep it in a properly shaped collodion bottle (see Fig. 130), and, after carefully decanting it without disturbing the sediment at the bottom, add about one-half per cent. of castor oil. The addition of this small quantity of castor oil makes a wonderful difference in the glaze of the finished picture, while materially assisting the toning.

The collodion being ready we take a glass measure capable of holding about 4 ounces. Into this place half an ounce of nitrate of silver and half an ounce of water. Thoroughly dissolve the silver, applying heat if necessary, and add 1½ ounces of alcohol, the addition to be made very slowly. Into another small measuring glass we dissolve 50 grains of citric acid in 1½ ounces of alcohol, and in another 48 grains of chloride of strontium are dissolved in 1½ ounces of alcohol.

Instead of chloride of strontium many other chloride compounds have been recommended, and may be employed, all varying in their effects. The principal advantage gained by the use of chloride of strontium lies in the color of the print; when toned it is possible to get with this emblem those rich purple-brown tints so much admired.

FIG. 130.

We have now four vessels, containing respectively the collodion, the silver solution, the citric acid solution, and the solution of strontium chloride. The next operation, when all the ingredients are thoroughly dissolved, is to add the citric acid solution to the strontium solution, and after well stirring together to place in another vessel containing 4 ounces of the plain collodion.

All the operations already described can be performed in strong daylight without any injury, but as we are now about to form the sensitive emulsion it will be necessary to remove our solutions, etc., to a room lighted only by a yellow light. Although a moderately non-actinic light is sufficient it should be remembered that the emulsion is more sensitive than sensitized albumen paper.

We now have the collodion containing the acid and the chlorine, and the silver solution. We mix the two together by dropping the silver solution into the collodion, stirring rapidly the whole time. The dropping is better effected by placing the silver solution into an ordinary dropping bottle. Too much care cannot be taken with this part of the process. It will be noticed that directly the drops of silver solution enter the collodion it takes a white, milky appearance. This is due to the formation of chloride of silver, and other compositions of minor importance, which remain suspended in the collodion. It being very necessary that the silver and the chloride be well distributed and thoroughly combined, the gradual addition of the silver solution and continual and violent stirring during the process are absolutely essential. If this is not observed an unevenness in the prints will be the result.

It must be mentioned that after the addition of the alcohol to the silver solution it very often happens that a portion of the silver crystallizes. As soon as this is observed the vessel containing it must be placed in warm water until the crystals are re-dissolved, when it must be immediately mixed with the collodion after the manner described.

We have now a sensitive collodion emulsion. It must be well shaken and allowed to stand for two or three hours. It must now be filtered in a collodion filter, and is then ready for use.

Our other method gives equally good results, but differs slightly in preparation.

Weigh out 2 drachms of silver nitrate and place it with 1½ drachms of water in a thin glass vessel that will stand heat. Place this in a pan containing hot water until the silver is dissolved; then remove it and add by dropping 4½ ounces of alcohol. If the alcohol is added too rapidly the silver will all crystallize in the solution. Should this happen, return the vessel to the hot water till the silver is again dissolved. It is much better, however, to carefully avoid the crystallization of the silver by adding the alcohol slowly and shaking it up well after each addition, for we have found that if allowed to crystallize and is remelted, there is always a tendency afterward for the silver salts to deposit themselves at the bottom of the collodion:

Next add about a quarter of an ounce of pyroxyline. As Simpson stated, the quantity of pyroxyline can only be determined by experiment, as it differs so materially in quality. In summer, too, a smaller quantity is required than in the winter. With ordinary commercial qualities and in mild weather, one-quarter of an ounce will usually be found about right.

After the gun cotton is added it is stirred round and round to get quite soaked through with the alcohol. This done, the ether is next added in the quantity of 5¼ ounces. The gun cotton or pyroxyline will immediately be dissolved and a collodion containing the silver nitrate is formed. We have next to add the chloride and other matter. In 1 ounce of alcohol dissolve 15 grains of lithium chloride, 15 grains of tartaric acid, 15 grains citric acid. When these are all dissolved the solution is gradually added to the silver collodion. Add it little by little, either with a dropping bottle or by blowing it in in a fine spray with a bottle such as is used for spraying perfumes. Shake the sensitive collodion up thoroughly so as to distribute the silver salts well over the emulsion and allow it to stand for several hours, when it is ready for coating.

The addition of about ½ per cent. of castor oil to the emulsion has the effect of making it less brittle and liable to crack when the paper is bent.

A very small quantity of sugar dissolved in alcohol and added will cause the collodion to adhere more firmly to the paper when it is coated on it, and so prevent it from peeling off.

The best kind of bottles for stowing and keeping the sensitive collodion are those long, sloping, yellow bottles, used to contain hock and other Rhine wines. The color of the glass is non-actinic in case any light should get to the dark-room, and further, the long sloping necks are particularly suitable in avoiding the formation of bubbles when the emulsion is poured out on to the paper.

Coating and Drying the Paper.—The most convenient method of coating the collodion paper is to work it in the same manner as a glass plate. If only small pieces are required, take a piece of paper, say, 11 x 13 inches, and lay it on to a 12 x 10 sheet of glass, so that it will just overlap the glass half an inch all round. In this way it is kept flat, and an experienced collodion worker could coat it without difficulty whatever. An amateur, however, would no doubt come quickly to grief, so that an easier method must be considered.

Sheets of baryte paper are usually about 20 x 24 inches in size. Make a double frame, hinged similar to that shown in Fig. 131. This is so arranged that when the sheet of paper is laid in between and the frames closed like a book, the paper is held fast and taut. The wood-work all round prevents the collodion from running over.

FIG. 131.

Hold the bottle containing the emulsion in the right hand and the board, with the paper laid on, in the left hand. Carefully wipe round the neck and sides of the bottle, and seee that there are no air-bubbles on the emulsion, then pour the collodion on to the right-hand upper edge of the paper. A little practice will soon enable you to judge the right quantity, but never be too sparing. With a gentle movement incline the board in such a manner that the emulsion flows well into the top left-hand corner, then down toward the bottom left-hand edge, and finally to the right-hand corner, where the superfluous collodion is allowed to run off. But have a care; not into the same bottle on any account if you are going to prepare another sheet, but into a separate wide-necked bottle. The bottle used to contain the emulsion for pouring on to the paper should not contain more than six or eight ounces, and should never be filled up higher than a couple of inches below the neck. The best bottles for this purpose I have found to be the wine bottles already referred to. They are usually of a non-actinic color, which is in itself an advantage. But the long gradual sloping neck prevents the formation of air bubbles. These latter will be found the chief enemy of the collodion worker, but with care and attention they can easily be got rid of. They are usually formed by pouring the collodion on to the paper at too great a height, or by bringing the bottle to an upright position with a jerk. All these little details, trifling as they may seem, are of great importance when good results are desired. The collodion must never be allowed to flow twice over the same spot during the one coating, or an unpleasant ridge visible in the finished print will be the inevitable result.

Carefully wipe the neck of the bottle each time, to prevent little pieces of the dried collodion from spoiling the film.

For the production of high-class prints it will be advisable to coat the paper twice. This is done when the first coating is thoroughly set. Turn the paper round the other way, so that the bottom and the top are reversed, and give another coating.

The superfluous collodion poured off into the wide-mouthed bottles is allowed to stand until the air-bubbles have entirely disappeared, when it can be used.

Owing to the speedy evaporation of the ether the collodion will soon become too thick. It should be thinned with a mixture of one part alcohol (.805) and two parts ether (.730). Well shake and allow to stand.

In pouring off the superfluous collodion from the paper gradually sway the board from right to left, in order to prevent the formation of ridges caused by the running of the collodion in one direction.

The collodion emulsion sets very rapidly; in warm weather about one minute, in winter three to four. When the superfluous collodion has run off, the paper is removed from the frame or support and hung up to dry by means of clips attached to a string.

Right here we come to another very important consideration, which must on no account be overlooked. We allude to the temperature in which these various operations of coating and drying are to be carried on. Paper prepared in a moist room and dried slowly gives flat prints, while if dried at too high a temperature will not tone at all.

The coating of the paper should be carried on in a cool, dry atmosphere, the room thoroughly well ventilated, as the fumes of ether and alcohol are exceedingly obnoxious and injurious to the health. Directly the paper is coated it should be taken and hung up in a room heated to about 60 degs. Fahr. After drying, the edges are trimmed with a pair of shears and the paper laid down flat under a heavy weight. It should be well preserved from light and moisture. If rolled with film outward if can be kept in an air-tight tin case, and when required for use will fall into a flat position if unrolled.

Coating by Machinery.—There is one advantage in coating collodion-emulsion paper—a smaller room only is necessary than with gelatine—as the paper dries very rapidly, and, consequently, does not require to be hung up in festoons.

In Fig. 132 we give an illustration of part of a collodion-emulsion coating machine. The paper coming from below passes round one roller, then down round another turning in the trough containing the collodion emulsion, then up and round another roller to a level position. It is very important that the paper should be brought to a level position as quickly as possible after it has received the collodion coating. For this reason, the two principal rollers should be as close to each other as possible—much closer in proportion than in the sketch, which is intended more to show the principle upon which the paper is coated. When the paper comes over to a horizontal position, it passes into a long tunnel box about one hundred feet long. The paper runs along a number of rollers at convenient intervals, every third or fourth being made to turn and drag the paper along. The tendency of the paper, when coated, to curl up at the sides, necessitates the arrangement of a number of bars fitted across about an inch or less above the rollers. This will effectually prevent the paper from curling up. If the tunnel be the length stated, and if a current of warm air is made to pass continually through it, the paper will be set and dry before it reaches the other end, arriving at which it can then be cut up into the sheets required as it comes out.

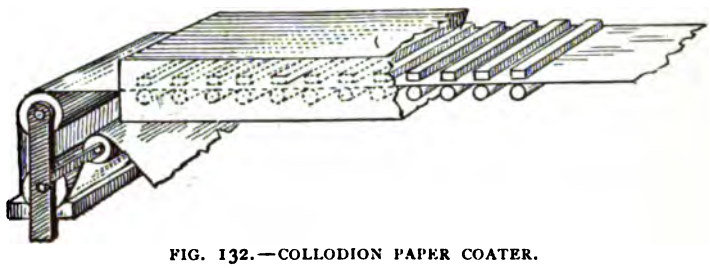


FIG. 132.—COLLODION PAPER COATER.

It is necessary that the current of warm air should be as even as possible without considerable variations of temperature. It should be made to pass through the tunnel and out through a pipe outside the building, as the alcohol and ether fumes are very dangerous and inflammable.

Printing and Washing.—In considering the depth that the print should be carried, much depends on the paper and on the subsequent operations. Many toning baths, for instance, have a strong reducing action.

Collodion paper is particularly sensitive to finger marks, which will produce red spots on the paper, as they stop the toning action on those parts. Handling the paper should, therefore, be avoided as much as possible.

In washing prints, previous to toning, we often have a difficulty to contend with that is not

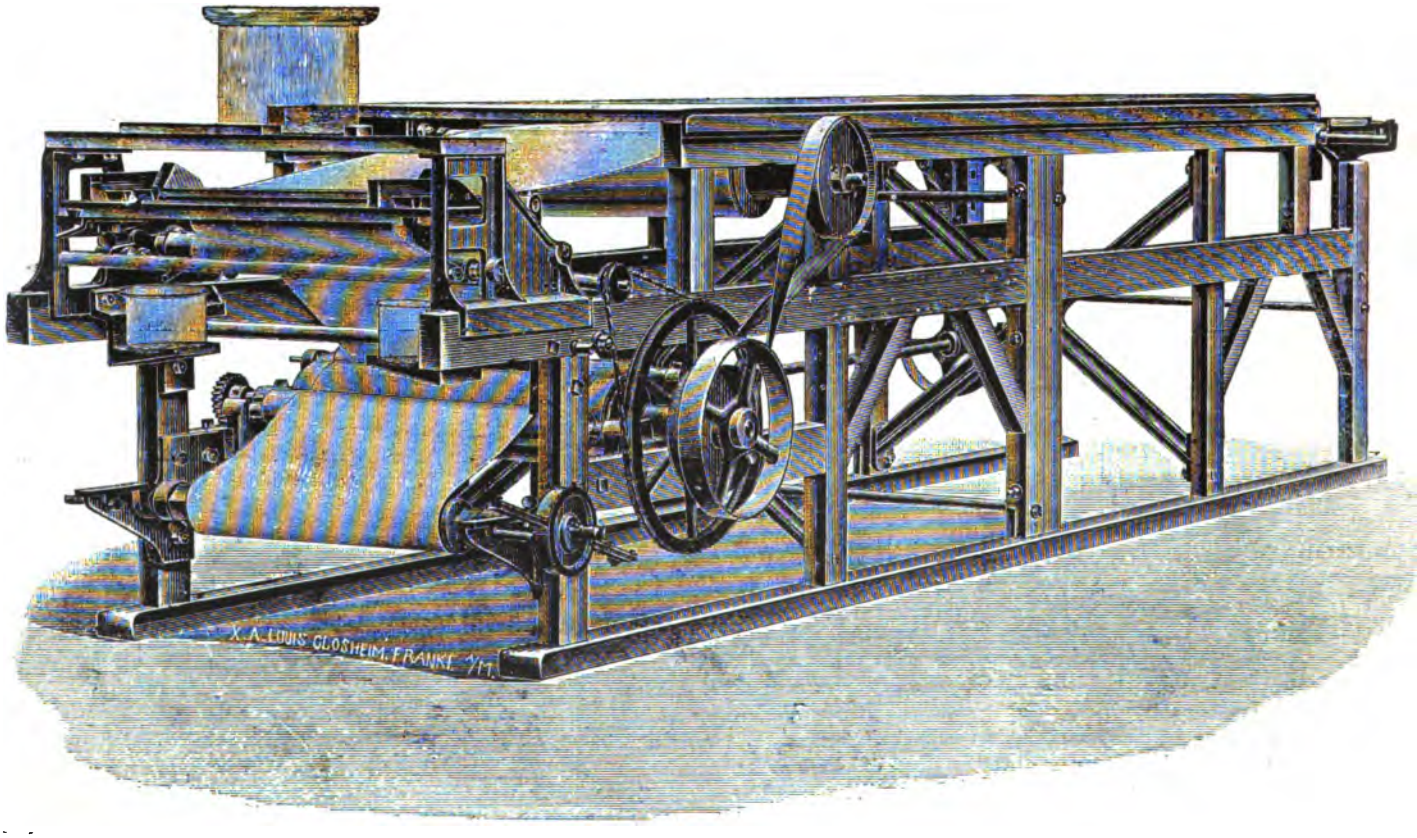


FIG. 133.—MACHINE FOR COATING COLLODION ARISTOTYPE PAPER.

met with in gelatine papers—we refer to the curling of the paper. Everyone is aware that paper expands very considerably when moistened; the gelatine film also undergoes the change, so that no apparent effect is produced. The collodion film, however, refuses to expand with the paper, hence it curls up inwardly, a process which causes considerable annoyance to the operator, especially in toning, as the action of the gold is then unequal. We must consider the various methods of avoiding this. If only small quantities are made, it is not a difficult matter to coat the back of the paper (either before or after coating with the emulsion) with an alcoholic varnish or with a plain collodion.

This method, however, has been found too costly to work commercially; the usual method to get rid of curling is to dip the prints directly into water raised to a temperature of 115 degs. Fahr., and then to lay them face downward on a slightly inclined tray, and pat them gently until no tendency to curl is apparent. In this position they should be allowed to remain for about ten minutes, after which washing should be continued, at the same time gradually reducing the temperature of the water until cold water can be safely used.

With collodion paper, the precautions against dampness are not so much needed as with the gelatine.

Another method is to place the prints, after washing, in a bath of alcohol, and from this direct to the toning bath.

Collodion prints require a thorough washing before toning, or the action will be uneven. It should be remembered that water does not permeate the collodion film so readily as the gelatine, although against this it must be said that the collodion film is far thinner.

Toning and Fixing.—Gaedicke is of opinion that collodion aristotypes require a much weaker toning bath than albumen or gelatine. It is certainly a fact that if the bath is too strong, a very uneven effect is produced. The process that he recommends is to wash the prints well in salt and water, rinse and tone in

Borax solution (1 per cent.)	1,000 parts
Gold solution (1 per cent.)	20 to 30 parts

The manufacturers of the Ilo collodion paper recommend the following:

TONING BATH (ready for immediate use).

Rain or distilled water	128 ounces (1 gallon)
Sulphocyanide ammonia, C. P.	310 grains
Chloride of gold, 15 grains dissolved in water	12 ounces

Pour the gold solution into the sulpho solution, giving you 140 ounces bulk. This bath keeps, and can be used repeatedly by adding gold and sulphocyanide ammonia.

Toning will be done in two or three minutes. If a warm tone is desired, prints must be taken out when quite red.

While for Kalona paper, which is also prepared with collodion, the following are given:

No. 1.

Water	48 ounces
Acetate soda	75 grains
Borax	75 grains

Add neutral gold enough to tone.

No. 2.

Water	48 ounces
Phosphate soda	90 grains

Add neutral gold enough to tone.

No. 3.

Water	48 ounces
Tungstate soda	150 grains

Add neutral gold enough to tone.

Have plenty of bulk to toning bath, so that each print is singly and thoroughly saturated. Toning baths should be made up at least twenty-four hours before using. Be sure toning bath is slightly alkaline at all times, testing occasionally with litmus paper. The toning bath should not work too quickly, from eight to twelve minutes for each batch of prints. After prints are toned, place in large intermediate water bath before fixing.

Fixing is done in

Hyposulphite of sodium	3 ounces
Water	64 ounces

In this solution the prints must be allowed not less than fifteen minutes.

A good plan, after this treatment, is to rinse them and immerse for five minutes in a fresh fixing bath. This method of double fixation is now very largely adopted, as it insures the complete elimination of the hyposulphites of silver.

The combined toning and fixing bath can also be used, and is preferred by many on

account of its simplicity and regularity. The instructions given with the Ilo paper for this method of treatment are as follows:

COMBINED TONING AND FIXING SOLUTION.

Hot water	½ gallon
Hypo.	16 ounces
Sulphocyanide ammonia	2 ounces
Acetate of lead	6 drachms
Nitrate of lead	6 drachms
Citric acid	4 drachms
Powdered alum	4 drachms
*Pure chloride of gold	12 grains

Dissolve thoroughly, then let it stand for twenty-four hours to settle, and use the clear portion. Bath of above proportions will tone and fix 500 to 700 cabinet size prints.

The bath must not be colder than 55 degs. nor warmer than 60 degs. Fahr. Take the temperature with a thermometer just before using, and if warmer than 60 degs., cool by adding a small piece of ice.

The amount of hypo in the toning and fixing bath must be kept up to the original standard, therefore a saturated solution of hypo should always be at hand—1 pound hypo to 2 pounds (1 quart) water. Measure the bath as you put it in your toning dish, so you will know just the quantity you are using. If you are using a quart, for every twenty-five or thirty pints toned and taken from the bath, add one ounce of this hypo solution to the portion of the bath you are using. If you are using a pint, add ½ ounce of the solution for every twenty-five or thirty pints toned and taken from the bath; and if you are using half a gallon, add 2 ounces of the hypo solution for every twenty-five or thirty pints taken from the bath, etc., etc.

You can use the bath over again as long as it will work and give satisfactory results. When you have finished, simply pour the portion you have been using into a separate vessel, and, to tone next batch of prints, use half old and half new bath.

Dissolve two or three bottles of the chemicals at a time, so you will have 1 or 2 gallons of the solution as stock always on hand. It keeps indefinitely in an open vessel, and, by having a quantity this way, you get much more satisfactory results. If your bath gets muddy, let it stand to settle, and use the clear portion and reclaim the balance by filtering.

Vogel is of opinion that, with collodion paper, the toning process should be as rapid as possible. When the time taken is too long, the fine details become gray, while the shadows keep warm.

Lead salts in the toning and fixing bath hasten the toning action. He recommends the following three combined toning and fixing baths:

	I.	II.	III.
Water	1,000	1,000	1,000
Hypo	250	180	250
Sulphocyanide of ammonium	28	24	30
Lead acetate	10	...	....
Lead nitrate	10	10	12
Citric acid	8	....	....
Alum	8	20	....
1 per cent. gold solution	40	100	100

Mounting and Finishing.—On account of the liability of the collodion film to peel at the edges, the prints should not be trimmed to the sizes required in mounting until after the final washing.

Trimming and mounting may be done as soon as the prints have all the superfluous water removed from them. Any ordinary photographic mountant can be used, as the precautions necessary with gelatine prints to preserve the glossy surface are here dispensed with.

Spotting defects in the print should be done in the usual manner, using a little albumen mixed with the color.

When the prints are *nearly* dry, they are in the best state for burnishing. The best effects are obtained by using a cold roller first, and, after a few minutes, a hot one, to give the high polish. The burnisher must not be too hot, or the pictures will redden.

COLLODIO-GELATINE PROCESS,—A process patented in 1856 by Dr. Norris. In this the collodion film, containing the sensitive silver salts, was immersed in a solution of gelatine, albumen, caseine, or any other similar substance. The object of this was to fill up the pores of the collodion film and prevent its condensation on drying, and retain it in a sensitive and pervious state. After treatment with the gelatine, the films were dried and exposed to the light, or could be kept for some time.

A more modern collodio-gelatine process has been devised by Messrs. Poirin and Graham. In this two emulsions are made, one of collodion and the other of gelatine. The plates are first

* The gold may be added as soon as the solution is settled, or just before toning, in proportion to the quantity to be used.

coated with a washed collodion emulsion, and then washed in hot water, and coated with a thin film of rapid gelatine emulsion.

COLLODIOTYPE.—A photograph produced by the collodion process.

COLLODION.—Collodion is prepared by dissolving certain nitrated products obtained from cellulose in a mixture of alcohol and ether. The cellulose employed for the manufacture of collodion is principally clean cotton-wool nitrated with a mixture of nitric and sulphuric acid of certain strength. Gun-cotton is the product of the extreme nitration of cellulose. When treated with sulphuric and nitric acids for a short time only, cellulose is converted principally into tetra-nitrate $C_{12}H_{16}(NO_3)_4O_6$ and penta-nitrate $C_{12}H_{15}(NO_3)_5O_6$, both of which dissolve in a mixture of alcohol and ether. The gun-cotton used for photographic purposes is usually a mixture, more or less complex of different nitro-products.

Collodion is a viscous fluid largely used in photographic operations. It is principally employed as a vehicle to hold the sensitive salts of silver. It is manufactured by dissolving soluble gun-cotton (pyroxyline) in ether and alcohol of varied proportions. A good collodion should be limpid and structureless, and the film should be smooth, soft, non-contractile, and possess a certain amount of tenacity. When dried upon a surface it should leave by the evaporation of the solvents a perfectly transparent film of pyroxyline. As the quality of the collodion depends almost entirely upon the kind of pyroxyline used, it would be well to study the remarks given under that heading.

For preparing a plain collodion, the following are two serviceable formulæ. The first is better adapted for winter work, and the second for the hotter summer months:

PLAIN COLLODION No. 1.

Pyroxyline	55	to 60 grains
Alcohol .820	4½	ounces
Ether .725	5½	ounces

PLAIN COLLODION No. 2.

Pyroxyline	55	to 60 grains
Alcohol .820	5	ounces
Ether .725	5	ounces

In making up collodion the alcohol should be added first to the pyroxyline, and lastly the ether. By this means its solution is aided. The proportions of ether and alcohol given above may be varied to suit the requirements of the operator. It should be noted that the larger the quantity of alcohol in proportion to the ether the slower will be the setting of the collodion; but if too much alcohol be added the film becomes streaky, and if the ether be in excess the film will be too contractile and liable to split in drying.

After the collodion is mixed, and the pyroxyline is dissolved, it should be allowed to remain undisturbed for two or three weeks. This will allow the insoluble particles to settle down, when the clear collodion can be decanted.

In making a plain collodion for emulsion processes, the chief points to be observed are the quality of the pyroxyline used, and the relative proportions of the alcohol and ether. If we take a sample of pyroxyline made at a low temperature and with strong nitro-sulphuric acid containing a minimum of sulphuric acid, it will be necessary to use only sufficient alcohol in the plain collodion to give the requisite solublity. This should be about a tenth or twelfth part by bulk of the amount of ether. Unless this precaution be taken, the iodized collodion will be very easily torn. It will also be so glutinous as to be difficult in working. It will adhere but loosely to the glass, and show peculiar structural markings and lines.

With a pyroxyline made from gun-cotton, with a large excess of oil of vitriol in the formula (see **Pyroxyline**), it is possible to use a larger quantity of alcohol. This has its advantages, as its contractility is lessened, and its setting properties are not so strong, and markings are thereby obviated. The following remarks upon the preparation of collodion, taken from Hardwich's "Photographic Chemistry," will be likely to be of service to those engaged in its preparation:—It will be found that with a tough kind of pyroxyline the solubility is increased by employing the maximum quantity of alcohol, so that if the plain collodion be diluted with ether a precipitate will take place. With other kinds of pyroxyline differently prepared, the addition of ether to the plain collodion produces no precipitate. In the case of pyroxyline prepared in a sulphuric acid containing equal bulks of oil of vitriol and nitric acid, with the maximum of water, it is advisable to reduce the quantity of alcohol somewhat, for if too much alcohol be employed, the setting of the pyroxyline will be so greatly retarded that the upper edge of the film will become dry before the lower part has solidified sufficiently to take the bath without precipitation of pyroxyline. This effect would not happen if the formula containing oil of vitriol in excess be used in the preparation of the pyroxyline, because it would be impossible to use such a mixture in a state sufficiently weak to destroy the property of setting in the resulting pyroxyline; before that point was reached the cotton would dissolve in the acid.

The effect of the presence of water is to produce viscidity in the collodion, and to cause a rapid decomposition when treated with the iodizer. It is therefore necessary that the exact strength of the alcohol used be carefully noted. Many collodion workers prefer to use a strong spirit. Absolute alcohol of a specific gravity of .805 at a temperature of 60 deg. Fahr. is used by many.

With the employment of a horny kind of pyroxyline, a small quantity of water seems to be necessary. The following useful remarks concerning the photographic effects of excess of alcohol in the collodion are also taken from Hardwich's work previously mentioned. The addition of alcohol to collodion lessens the contractility of the film, and renders it soft and gelatinous. These conditions are favorable to sensitiveness, perhaps from the play of affinities being promoted by the loose manner in which the particles of iodide are held together. The extra sensitiveness obtained by the use of alcohol, however, does not increase after a certain point; on the contrary, it diminishes, for it appears to be necessary to extreme sensitiveness that the film should coagulate within a certain time after it has been coated, and, therefore, the addition of alcohol must be stopped when the film loses its ready setting qualities, and is not coherent under the finger. Hence a porous collodion is soon injured in sensitiveness on adding too much alcohol, but a strong and tough pyroxyline will bear equal bulks of the two solvents without loss in that respect. These observations as to the effect of excess of alcohol in diminishing the sensitiveness of the film to dark objects apply particularly when the atmosphere is cold and damp, and evaporation is retarded. At a very high temperature, and in a dry air, it does not apply, since the presence of alcohol is then useful in preventing the film from becoming surface dry, especially when it is necessary to keep the sensitive plate for a long time between exposure and development.

To get a good textureless film a method of refining the pyroxyline should be adopted. This is accomplished by making a plain collodion with cheaper solvents and half the quantities given. This is then poured into cold water in a fine stream. The effect of this is that a portion of the pyroxyline remains in solution in the water, and a portion becomes precipitated, and is of a finer quality than the original. This should be dried and again made up into collodion.

ENAMEL COLLODION.

Alcohol (.82)	48 ounces
Ether (.72)	84 ounces
Pyroxyline	1 ounce
Castor oil	10 minims

TRANSFER COLLODION.

Alcohol (.805)	10 ounces
Ether (.73)	5 ounces
Pyroxyline	½ ounce
Castor oil	¼ ounce

COLLODION FOR POSITIVES.

Alcohol (.805)	10 ounces
Ether (.72)	10 ounces
Pyroxyline	100 grains
Ammonium bromide	20 grains
Cadmium iodide	50 grains

LEATHER COLLODION.

Two per cent. collodion	100 parts
Castor oil	4 parts

Collodion should be kept in long narrow bottles, to allow of the collodion being drawn off when all the impurities have settled.

Plain collodion sold by dealers usually contains about five per cent. of pyroxyline. Methylated alcohol and ether may be and are chiefly used in manufacturing collodion owing to their cheapness. It may be useful to point out that collodion is an excellent substance to cover over wounds with, and to stop loss of blood. Should the photographer or any member of his household be so unfortunate as to get cut or wounded, a little plain collodion should be poured on. When set it forms a strong skin, and prevents the emission of blood and the admission to the wound of injurious matter.

COLLODION-ALBUMEN EMULSION.—A collodio-albumen emulsion. A process introduced by Captain Abney, and thus described by him. The following is the mode of preparation: Sixteen grains of ordinary cotton are dissolved in 6 drachms of ether (.730) and 4 of alcohol (.805), and the plain collodion thus formed decanted. Twenty grains of zinc bromide are dissolved in a small quantity of alcohol, and enough bromine water added to tinge the solution with a pale yellow. This is added to the above amount of plain collodion. To each half-ounce of the above, one grain of dried albumen is taken and dissolved in the least possible quantity of water, or eight drops of the white of an egg may be dropped into a drachm of alcohol and thoroughly stirred. Either of these solutions is then carefully dropped into the collodion, placed in a jar, and well stirred up. This should form an emulsion of albumen in the collodion. Forty grains

of silver nitrate are next added, after having been dissolved in the smallest possible quantity of water and boiling alcohol. A beautifully smooth emulsion should result from this. The amount of silver nitrate added ensures that there is an excess of at least two grains in each ounce of the emulsion. Instead of the emulsion being made entirely of zinc bromide, greater density can be obtained by omitting four grains of it and replacing this by four grains of calcium chloride. The emulsion is next poured into a dish and the ordinary manipulation carried out.

After a couple of washings it may be advantageously covered with a weak solution of silver nitrate, and again washed till the traces of silver are very faint. The pellicle should be redissolved in equal quantities of ether and alcohol, and finally there should be about seven grains of the pyroxyline as originally used to each ounce of the mixed solvents. The emulsion when finished gives a tender blue by transmitted light, and is seemingly transparent. It may have a tendency to curl off the plate on drying, in which case the addition of a little ordinary washed emulsion will correct it. It will develop with plain pyrogallic acid, and can be intensified by pyrogallic and citric acid, with the addition of a few drops of silver nitrate solution, or it can be developed with the alkaline developer, the ferrous oxalate developer, or the hydrosulphite developer. If the developer be kept above a temperature of 60 deg. Fahr., the tendency to blister will be prevented.

The image obtained by this process is usually very delicate and thin, and the exposure required is a little less than for an ordinary wet plate.

COLLODION DRY-PLATE PROCESS.—The first published practical formula for a collodion emulsion was that by Messrs. Bolton and Sayce in 1864.

With this process a dry collodion emulsion is used, and before going farther it will perhaps be best to explain the difference between the collodion "dry" and the collodion "wet" process. In the wet process we coat the glass with a collodion containing the bromide or the iodide, or both, and immerse it in a nitrate of silver solution. The effect of this is explained in the description given of that process. The silver combines with the bromide or iodide to form the sensitive compound. In the dry collodion process the effect is similar, though the manipulation is different. To the liquid collodion containing the salts the silver nitrate is added, and the sensitive emulsion thus produced is spread on to glass plates and dried. The advantage of this is that after the preparation of the plates they may be kept for some time previous to the exposure, which is not the case in the wet process.

Dry collodion emulsion processes must be divided into two distinct classes, the "washed" and the "unwashed." When the silver is added to the salted collodion a process of double decomposition takes place by which the sensitive salts are formed. But besides these other compounds or bye-products are produced, which, if they were allowed to remain in the film, would crystallize and spoil the plate. It is therefore necessary that these be removed, and this is done either by washing the emulsion before coating the plates, or by washing the film after the plate is coated. The first process is termed the "washed" emulsion process, and the latter the "unwashed" emulsion process, although it will be seen that in both cases the washing takes place at one stage or another. For description of the two processes see **Collodion Emulsion Process**, also **Beechey's Process, Dawson's Process, Lea's Process.**

COLLODION EMULSION (washed).—A plain collodion is first made up after the following formula:

Alcohol, .820	5 ounces
Ether, .720	10 ounces
Pyroxyline	200 grs.

If a plain collodion, as sold by dealers, be used it should be remembered that the amount of bromide silver should be regulated according to the number of grains of pyroxyline in, and not according to the amount of collodion. As a rule, commercial plain collodion contains about 5 grains of pyroxyline to the ounce, after the addition of the iodizer.

To one-quarter of the collodion, or 3¾ ounces, we must add 100 grains of zinc bromide. This is done by dividing the amount into two parts of 50 grains. One part is dissolved in a very small quantity of alcohol, and two or three drops of concentrated nitric acid added to it, and the whole is then added to the collodion. The other 50 grains of the zinc bromide is similiarly dissolved in the smallest quantity of alcohol, and five or six drops of the nitric acid added. This should be kept in a convenient test tube ready for use. We next take 165 grains of powdered silver nitrate and place it in a test tube with 2½ drachms of water. The test tube is then slightly warmed, when the silver should be completely dissolved, and when this is so, five drops of nitric acid are added to it. In another large test tube, or other convenient vessel, ¾ ounce of alcohol .830 should be boiled and poured on to the silver solution. The two solutions are thoroughly mixed by repeatedly pouring them from one test tube to another. We have now the collodion, the zinc bromide solution, and the silver solution. With these we retire to a room lighted only by yellow light.* The collodion is placed in a large jar, and the test tube

*Abney is of opinion that the exclusion of light is quite unnecessary, owing to the presence of nitric acid, which renders the sub-bromide inert as fast as it is formed by the action of light, and that the whole of the operations up to the first washing may be carried on in the light.

containing the silver is held in the left hand, and a glass stirring rod in the right. About three parts of the siver solution is then added drop by drop, vigorously stirring with the rod. The silver solution is then changed for the bromide, which is also added drop by drop. After this addition, the remaining portion of the silver solution is added. If any of the silver be found to have crystallized on the sides of the tube, it is redissolved in a little water and alcohol. After all the additions have been made, the emulsion which is now formed is briskly agitated to thoroughly mix the various ingredients, and a drop of the emulsion placed on a piece of glass and viewed by transmitted light. The color of a candle or gas flame should be of a deep orange tint. A little of the emulsion on to a piece of glass is then carried out into the daylight, a little potassium chromate is dropped on to it, and it should instantly turn a bright red color, proving silver to be in excess. The emulsion being satisfactory is decanted into a bottle capable of holding about 12 ounces, and well shaken up. It is then laid aside for twelve to fifteen hours to ripen. In about ten and a half hours it will have attained its maximum sensitiveness. It is now ready for washing. This is accomplished by pouring the emulsion into a large flat dish, so that its depth is not more than a quarter of an inch. The solvents will rapidly evaporate, and a skin will form on the surface; this is broken up, and the emulsion well stirred up. This is repeated every now and then until the emulsion forms into lumps. It is then placed into a glass vessel and covered with distilled water. On the addition of the water some of the lumps will rise to the surface. Only a small portion of it should float, however. If much of it does, the evaporation of the ether and alcohol has been insufficient. If half a drachm of nitric acid be added to the distilled water freedom from fog will be secured. After a couple of hours the emulsion, or pellicle as it is now termed, is thoroughly washed in a running stream of water. A good method is to place it in a china or earthenware teapot. The lid is removed and a piece of fine muslin is tied over the top, and a stream of cold water sent down the spout for several hours.

The next operation is to remove the water contained in the pellicle. It is first transferred to a piece of muslin, and as much of the water squeezed out as possible. It is then placed in a vessel and covered over with alcohol. After about an hour it is again squeezed as before, and again covered with alcohol. At the expiration of another half hour the alcohol is drained off, and the pellicle is ready for emulsifying. If necessary it can be dried by a few hours' exposure to the air, and kept for future use in a dry state.

The moist pellicle is next dissolved according to the following formula:

Pellicle	100 grains
Alcohol (.820)	3 ounces
Ether (.720)	3 ounces

A trial plate should be coated with this, as it may be necessary to dilute with more alcohol and ether.

The plates are then coated and dried.

COLLODION EMULSION (unwashed).—In this process the emulsion is not washed until after the plates are coated. The first operation is the manufacture of the collodion, which is done after the following formula:

Sulphuric ether (.720)	7 ounces
Alcohol (.820)	4 ounces
Pyroxyline (high temperature)	70 grains
Zinc bromide	120 grains

The pyroxyline is described as "high temperature." This will be clearly explained under **Pyroxyline.**

The ingredients of the above formula should be mixed in the order that they are given, and allowed to stand one clear day.

One hundred and eighty grains of silver nitrate are then dissolved in a test tube with 90 minims of boiling distilled water. In another test tube 1½ ounces of alcohol are boiled, and when both solutions are at their boiling points add 1 ounce of the alcohol to the silver solution. The test tube containing the silver solution, the tube containing the remaining ½ ounce of alcohol and the bromized collodion, are next all removed to the dark-room—a room lighted only by yellow light. The silver solution is then added drop by drop to the collodion, which is kept violently agitated with a glass stirring rod. When all the silver solution has been added, the remaining ½ ounce of alcohol is poured into the tube to dissolve the crystallized silver, which will probably form, and it is then added to the emulsion. The whole is then well shaken, and the collodio-bromide emulsion, which is now formed, is left several days to ripen.

When thoroughly "ripened" the emulsion is filtered through a funnel containing a tuft of cotton-wool.

Glass plates thoroughly cleaned and polished are provided with an albumen substratum or an edging of india rubber solution. The method of making the substratum is as follows: The white of an egg is beaten up in 40 ounces of water, and a small quantity of ammonia is added until its smell is distinctly perceptible. The whole is then allowed to stand, and filtered

carefully. This solution will keep for a great length of time, provided a little ammonia be added when necessary.

With this solution the clean and wetted glass plate is flowed twice over and dried. The plate is then coated with the collodion emulsion, and when it is set the plate is plunged into distilled water, and afterwards washed in clean water until all trace of greasiness has disappeared. The preservative is then applied and the plates dried for use.

COLLODION EMULSION PROCESS.—It is intended under this heading to describe the preparation and manipulations of the dry collodion plates. In other places it has been pointed out that there are two distinct methods of preparing the emulsion—the one termed the "washed" emulsion process, and the other the "unwashed" emulsion process. Under collodion emulsion will be found descriptions of making both these emulsions, the descriptions leading up to the preparation and coating of the glass plates. We will now give the process *en detail* of preparing the plates, and the developing and finishing of negatives upon them.

The emulsion used can be either the washed or the unwashed; when any difference is necessary in the manipulation it will be pointed out.

The glass plates to be coated are first soaked in nitric acid and water, and then washed with cold water, rubbed over with tripoli powder and alcohol, and allowed to dry. The plate is then polished with a silk handkerchief or soft cloth, and coated with the following substratum:

White of egg	1 ounce
Water	100 ounces
Ammonia (.880)	6 drops

This should be well shaken and filtered. The plate is first rinsed in distilled water, and the albumen solution flowed over it and drained off as quickly as possible. Another method is to apply the solution with a Blanchard's brush. Instead of albumen some workers prefer india rubber as a substratum. The formula is 1 grain of india rubber dissolved in an ounce of chloroform or benzole. This is flowed over the plate in the same way as collodion. When the plate has been provided with the substratum it is ready for coating with the emulsion.

The emulsion thoroughly filtered is placed in a convenient pouring bottle. It is then poured on to the plate in the usual manner. If the collodion "drags," it should be diluted with a small quantity of ether and alcohol in the proportion of two parts of the former to one of the latter.

The collodion is made to flow over the whole of the plate, and the overflow is returned to another bottle, and the plate kept rocking to and fro to prevent the formation of lines and ridges.

If the emulsion be a "washed" one the plates should now be dried and treated with a preservative (see **Preservative**). An arrangement for the convenient drying of the plates was recommended by Woodbury. It consists of an ordinary iron tripod stand, a flat piece of sheet iron, and a spirit lamp or gas burner. The lamp or burner is placed under the iron tripod, upon which is rested the iron plate. A few pieces of blotting paper are laid upon the iron plate, which is then heated by the burner underneath until the blotting paper is inconveniently warm. Upon this the plates are then laid, and the drying will be very rapid. In applying the preservative to a washed emulsion the plate should first be washed with water until all trace of greasiness has disappeared. If an unwashed emulsion is used it is first thoroughly washed in distilled water until all the silver nitrate that is in excess be thoroughly eliminated. They are then flooded with a preservative solution and placed in a drying cupboard to dry.

With many emulsions of this description the films are so translucent that to avoid halation it is necessary to provide the plate with a backing (see **Backing**), which must be removed after exposure.

The exposure necessary with this kind of plate is rather long compared with the modern dry-plate process.

For development perhaps the most suitable developer is that recommended by Colonel Wortley. The film of the exposed plate is first flowed over with—

Alcohol	1 part
Water	1 part

This will soften the film. It is then washed under the tap, and the developer applied. This is made up with—

SOLUTION 1.

Pyrogallic acid	96 grains
Alcohol	1 ounce

SOLUTION 2.

Potassium bromide	120 grains
Water	1 ounce

SOLUTION 3.

Liquid ammonia .880	6 minims
Water	1 ounce

To develop, the following proportions are taken:

Solution 1	6 minims
Solution 2	3 minims
Solution 3	3 drams

The plate is laid in a flat dish, and the developer poured over it. Its action is not rapid, but after a little time the image should appear slowly and gradually. It should gain strength as it goes on, and be free from veil. If after the image does not appear readily, a fresh developer should be made with only half the quantity of Solution 2.

If the developed negative is lacking in brilliancy it can be intensified with an ordinary acid intensifier.

SOLUTION 1.

Pyrogallic acid	3 grains
Citric acid	3 grains
Water	2 ounces

SOLUTION 2.

Silver nitrate	30 grains
Water	2 ounces

The plate is first of all thoroughly washed. Solution No. 1 is then flowed over the plate, and returned to a cup containing five or six drops of Solution 2 dropped into it. This is then returned to the plate, and then intensification should be carried on until the required density has been arrived at.

With these plates the ferrous-citro-oxalate developer can also be used. Abney's formula is—

Potassium citrate (neutral)	100 grains
Ferrous oxalate	22 grains
Water	1 ounce

The potassium citrate is first dissolved in a flask by heat, and when nearly at boiling point the addition of the ferrous oxalate is made, and shaken up in it. When cold it should have a citrony-red color. Its action in development is rather slow.

After development, and, if necessary, intensification, the plates are fixed with—

Potassium cyanide	10 grains
Water	1 ounce

Or—

Sodium hyposulphite	1 ounce
Water	8 ounces

The objection to the former fixing agent is that it is a most violent poison, and no little care must be taken in its use. When thoroughly fixed the plates are dried spontaneously, and then varnished to protect the films.

COLLODION FERROTYPES.—See **Collodion Wet Process for Positives.**

COLLODIONISED PAPER.—Paper coated with a film of collodion. It can be used for painting on with oil colors. Photographs if coated with collodion may be painted over in oils. Very effective pictures are now made in this manner. They are mostly reproductions or miniatures of paintings in the Paris Salon.

COLLODION TRANSFERS.—These are usually produced by coating a sheet of talced glass with an iodized collodion, sensitizing, developing, fixing, etc., after the usual manner. The film is then transferred to a sheet of carbon double transfer paper. This process is often used for enlarging, and is more carefully described under that heading.

COLLODION WET PROCESS.—A process in which collodion forms the vehicle to hold the sensitive salts. It is commonly known as the wet-plate process, in contradistinction to the dry-plate process, the film being exposed in the one case whilst wet and in the other when dry. Before describing the process in detail it will, perhaps, be better to give an outline of it. A collodion is first prepared, in which are dissolved bromides and iodides. A perfectly clean glass plate is then coated with a thin film of this collodion, and as soon as this is set it is immersed in a solution of silver nitrate (see **Silver Bath**), the silver forming with the salts in the collodion, silver-iodide, or silver-bromo-iodide. The plate is then exposed in the camera, and afterward treated with a developing solution, which brings out the image. This is then intensified or strengthened and then fixed. Lastly, the collodion is given a protective coating of varnish, and the negative is ready for the printing processes.

Cleaning the Glass.—The importance of having the glass clean cannot be over-estimated. It should be well rubbed with a mixture of alcohol and tripoli powder, sufficient to form a cream;

about ten drops of liquid ammonia is then added to each ounce of the cream. Should the plate have been used before, it should be previously laid in a weak aqueous solution of nitric acid. A soap commonly known as "Monkey soap" is an admirable cleanser of glass, removing all traces of grease and organic matter. Common whitening will also remove grease when dry. It should be made into a thick cream with water and applied to the glass, and rubbed off when dry. With regard to the selection of the glass, a careful perusal of the few remarks under **Glass** might be advantageous to the reader.

Salting the Collodion.—The particulars regarding the necessary qualities required in the plain collodion are given under that heading. It will not, therefore, be necessary to repeat them here, but pass on to the addition of the iodide or bromide to the collodion. The following is the standard formula:

Cadmium iodide	4½ grains
Cadmium bromide	2 grains
Plain collodion	1 ounce

This should be mixed about six months previous to using. For landscape work the following is to be recommended:

Ammonium iodide	4 grains
Cadmium bromide	1¼ grains
Plain collodion	1 ounce

This may be used two or three days after mixing. A large number of modifications have from time to time been recommended. The following rules may guide the operator: Should a decrease of contrast and plenty of detail be required, add more bromide; but if great contrasts are necessary, lower the quantity of bromide, and increase the iodides. The lowest quantity of bromide necessary to secure clearness in the shadows is about one-quarter grain to the ounce of collodion. The iodides and bromides used are usually ammonium and cadmium. If ammonium be used the collodion is more fit for immediate use; cadmium causes collodion to become glutinous when first iodizing, and it is therefore necessary to keep it for several months previous to using. If an iodide alone be used the resulting image will be very dense, but lacking in detail in the shadows; and if a bromide only be used a much flatter image, but full of detail, will be obtained. It will therefore be seen that by a judicious mixture of the two a suitable film can be made, which, when sensitized, will give the detail and delicacy of the bromide combined with sufficient density of the iodide, or a mean between the two extremes.

The plain collodion should always be kept in a cool, dry place, otherwise the ether is liable to decompose, and in its turn decompose the pyroxyline. If the collodion be made with a pure spirit and a neutral cotton it should be quite colorless after iodizing, but should any of the solvents be impure a slight discoloration will result, as the contact of iodine with ether compounds will sometimes form an organic compound. Again, if the pyroxyline be acid, the collodion will become sherry colored immediately, and will keep good for any length of time.

The customary method of iodizing a collodion is to omit half the quantity of alcohol in the plain collodion, and use it to dissolve the iodide or bromide which is then added. The addition of the iodide or the iodide and bromide to the plain collodion is termed iodizing, and the collodion is said to be iodized.

All good workers with collodion adopt the method of writing upon the label of the iodized collodion the date of its manufacture, the date when iodized, and the various ingredients and proportions used in both processes. This will be found of much use, and a convenient guide for future operations.

It may be as well to state that both time and trouble may be saved by those who object to lengthy processes by purchasing the iodized collodion sold in the market ready for use.

Coating the Plate.—The next operation is to coat the glass with the collodion. It is one that requires no little care. The iodized collodion is kept in a suitable bottle, guarded from dust, and free from solid particles of dry collodion. The form of the bottle should be similar to that depicted in fig. 130, which permits of the collodion being poured out evenly, and prevents the formation of bubbles and solid particles from settling on the film.

The glass, cleaned and polished, is held at one corner by the thumb and first finger of the left hand by allowing the extreme corner to press into the ball of the thumb, and the under side of the glass to rest upon the first finger bent into position to receive it. By this means touching the upper surface is avoided, and the collodion can be coated over the whole of the surface of the glass save a very small corner nearest the thumb. A still better method is to employ a pneumatic holder, which can be attached to the back of the glass and allow the whole surface to be coated. The glass plate is first dusted over with a broad camel-hair brush, scrupulously clean, and a pool of the collodion, of more than sufficient quantity to cover the glass plate, is poured on towards the top right-hand corner. The plate is then slowly tilted to allow the collodion to first run in and fill up the top right-hand corner without overflowing. The collodion is then made to run along the plate to the top left-hand corner, and then to the bottom left-hand corner. Another movement of the plate serves to bring it to the bottom right-hand corner, the whole of the

plate having been covered. From this corner the superfluous collodion is poured off the plate into another bottle, rocking the plate from side to side to prevent the collodion leaving traces of its downward flow towards the bottle. As soon as the collodion is "tacky" it is placed into the "nitrate" or "silver bath."

The coating a glass plate with collodion requires considerable practice; it will therefore be as well for the operator to make his first attempts with spoilt collodion, glycerine, or thin cream.

The Silver Bath is one of the most important solutions used in wet-plate photography, and upon its purity and strength a great deal depends. The salt invariably used is the silver nitrate, and this should be of the purest quality obtainable. The strength of the solution varies. With a collodion which contains iodides and bromides the greatest strength permissible is 50 grains of silver nitrate to each ounce of water. According to Abney, even this proportion is too large, since the silver nitrate in solution will dissolve up a certain amount of silver, the quantity depending upon the silver solution and on the temperature. If, therefore, it were not that the solution becomes saturated with silver iodide on the immersion of a collodion film, the iodide would be dissolved out, either partially or wholly, according to the time of the immersion. Now, as it is easier to saturate a dilute than a strong solution, and as a variation in the temperature will cause a less marked difference in the former than in the latter, it will be evident that the less the amount of silver salt in solution, the greater the probability that the solution will not show signs of under or over-saturation of iodide.

Another point to be observed is the acidity or alkalinity of the bath, as upon this the sensitiveness of the plate partially depends. If a collodion be used containing an iodide only the bath should be either neutral or very slightly acid, but with a collodion containing bromide and iodide it should be distinctly acid unless a considerable amount of free iodine be present.

For a bromo-iodised collodion the following sensitizing bath may be used:

Silver nitrate (re-crystallized)	40 grains
Distilled water	1 ounce
Potassium iodide	⅛ grain

This is made up by dissolving the silver nitrate in a quarter of the quantity of water. The potassium iodide is next added. This will form silver iodide, and will be partially re dissolved when the solution is agitated. The remaining quantity of water is then added, and a re-emulsification of the silver iodide will take place. It is then filtered and tested for acidity or alkalinity. A piece of blue litmus paper after immersion for a minute in the solution should redden slightly. If it redden immediately on immersion a small quantity of sodium carbonate should be added. This will form a precipitate, which is then filtered out, and a few drops of nitric acid solution (1 to 12 of water) added. If the litmus paper remains blue on immersion a small quantity of the nitric acid solution must be added. Instead of nitric acid acetic acid is sometimes used. With this, however, silver acetate is sometimes formed, which is not easily eliminated.

The silver bath will after a time become supersaturated with iodine or ether and alcohol. The presence of iodine is indicated by "pinholes" in the negatives. To eliminate, the bath should be diluted to about one-half its strength, and silver nitrate added to make up to its original strength. It should then be filtered. If ether and alcohol be present, unequal sensitizing and streaky development will be the effect. If the bath be gently heated, both the alcohol and ether will be driven off. The presence of organic matter in the silver bath will result in foggy, dirty, veiled negatives. The removal of this is not easy. The solution should first be made distinctly alkaline with sodium carbonate, and then placed in the sun for some days. A black deposit will be formed in the bottle, and the liquid should be filtered, acidified with nitric or acetic acid, and again filtered. The bath prepared, we have next to sensitize our plates, coated with the iodized collodion, by immersing them in it.

FIG. 134. SILVER BATHS. FIG. 135.

Sensitizing the Plate.—We have already stated that the glass coated with the collodion is, when in a tacky state, ready for immersion in the sensitizing bath. This is usually done by employing what is termed a dipping bath (figs. 134, 135). This is made of glass, enclosed in a wooden box supported in an upright position. Into this the silver solution is poured. The collodionized plate is laid upon a dipper made of ebonite or porcelain, and plunged into the silver solution, the lower end of the plate being immersed first, as the collodion is probably thicker at that part. This operation is, of course, done in non-actinic light. In a few seconds the plate will be seen to change to a grey,

or bluish grey color, according to the salts in the collodion. This is due to the double decomposition of the silver haloids giving a layer of silver bromide or iodide, thus:

$$NH_4I + AgNO_3 = AgI + NH_4NO_3$$
$$CdBr_2 + 2AgNO_3 = 2AgBr + Cd(NO_3)_2$$

After the plate has been immersed in the bath for about forty-five to fifty seconds it should be gently raised. When there is no longer any appearance of greasiness on the plate the sensitization is complete. It is then raised slowly from the bath, and the solution at the lower end blotted off on to clean blotting paper. The back is then wiped with the same material, and the plate placed into the dark slide of the camera. A special kind of slide is necessary, in which the plate is kept in position by glass or silver corners. A piece of damped red blotting paper is next placed behind the plate, and the slide closed, and the plate is ready for exposure. After exposure the plate is returned to the dark room, and is ready for development.

The Developer.—There are two methods of development, *i.e.*, iron and pyrogallic acid. The latter is but rarely used at the present time, since the former has been discovered to be such a superior reducing agent. If, however, a collodion is employed containing an iodide only, the pyro developer may still be used. It gives a very dense image, and for this reason is specially useful for copying purposes. A longer exposure is necessary than with the iron developer. The pyrogallic developer is made up in the following manner:

Pyrogallic acid	1 grain
Glacial acetic acid	20 minims
Alcohol	quant. suf.
Water	1 ounce

The most suitable developer in this process is undoubtedly the ferrous sulphate; a convenient formula runs:

Iron protosulphate	12 grains
Acetic acid (glacial)	20 to 25 minims
Water	1 ounce
Alcohol	quant. suf.

Instead of acetic acid, 1 minim of nitric acid may be used. No definite quantity of the alcohol can be given, as it must be regulated by the amount of alcohol in the bath. For instance, a new bath requires a very small quantity of alcohol in the developer, but as it grows old the quantity of alcohol in the developer must be gradually increased, or streaky development will be the result.

The iron should be quite fresh, and of a light green color. Iron which has been exposed to the atmosphere for some time becomes oxidized, having a yellow coating, which, if used for development, acts as a powerful restrainer.

Another formula which is used by several photographers for landscape work is:

Ferrous sulphate	20 grains
Copper sulphate	10 grains
Acetic acid (glacial)	15.20 minims
Alcohol	quant. suf.
Water	1 ounce

This will give very clear and brilliant images, and the exposure is said to be shortened.

A formula for a developer giving very intense images is the following:

Protosulphate of iron	36 grammes
Sulphate of copper	12 grammes
Water	1000 c.c.
Glacial acetic acid, 85 per cent	50 c.c.
Alcohol	40 c.c.

The addition of many organic substances to the developer has been recommended. Gelatine, sugar, glycerine and collocine, if added to the developer, cause the silver to deposit much slower, and greater density is obtained. A developer containing an "organifier," as it is termed, is made up as follows:

Ferrous sulphate	20 grains
Acetic acid (glacial)	10 to 15 minims
Lump sugar	10 grains
Alcohol	quant suf.
Water	1 ounce

Developing the Image.—The plate is removed from the dark slide, and held over the sink either by one corner or preferably with a phneumatic plate-holder. The developing solution is placed in a developing cup, and a sufficient quantity of it to well cover the plate is swept over in one wave, entirely covering it in one operation, but if possible without spilling the solution. Practice alone will enable the operator to do this successfully. The developing

solution is kept moving over the plate for twenty or thirty seconds, when it is either thrown away or transferred to the residue jar. If the image flashes up quickly, and is of an even gray, the exposure has been too great, and if, on the contrary, it comes up tardily, or in black and white patches, the exposure has been too short. This is, of course, supposing that all the previous operations have been correctly carried out.

If development has not been carried out far enough the plate can be washed under the tap, and a fresh supply of developer applied. If a small quantity (ten drops to each ounce of developer) of a ten per cent. solution of silver nitrate, acidified with nitric acid, be added, it will give considerable increase in both detail and density. This is termed re-development, and should only be practised if the image, after the first application of the developer, is weak and wanting in detail. If, however, it be weak, and yet full of detail, intensification is necessary.

Fixing.—The plate is, after development, washed and fixed by pouring on—

Potassium cyanide	25 grains
Water	1 ounce

Or—

Sodium hyposulphate	100 grains
Water	1 ounce

In one of these solutions the plate must remain until the yellowness disappears entirely from the plate. If potassium cyanide be used as a fixing agent it should be remembered that it is a violent poison; even its fumes dangerously affect some persons.

After fixing, the plate is well washed in water.

Intensifying the Image.—If the plates are wanting in density the image must be intensified. The plate is taken on a pneumatic holder and flooded with—

Pyrogallic acid	2 grains
Citric acid	2—4 grains
Water	1 ounce

Or—

Ferrous sulphate	6 grains
Citric acid	12 grains
Water	1 ounce

The pyro intensifier brings up the image much quicker than the iron, which is suitable for a picture that has been properly exposed.

Another method of intensifying collodion wet plates is with an alkaline solution of silver. This method was first pointed out by Abney in 1874, and worked out later by Mr. Farmer. The following is a description of the method:

A.

Silver nitrate	1 ounce
Water	12 ounces

B.

Potassium bromide	½ ounce
Water	2 ounces

C.

Sodium hyposulphite	2 ounces
Water	6 ounces

Add solution B to A, and after washing the precipitated bromide thoroughly by decantation, dissolve it with agitation in C. The liquid will at once become muddy, when it should be either filtered clear, or allowed to stand for a day or two and the clear part filtered off. It is then made up with water to sixteen ounces and kept ready for use. Other intensifiers are given under that heading. Intensifying may be done either before or after fixing. If the image is clear and free from fog, intensification is best accomplished before fixing, but if the plate has been over-exposed it is best done after fixing, as before fixing it acts as a developer and would produce fog.

After intensification and fixing the plate is thoroughly washed and dried. If dried quickly by the application of heat the density of the negative will be slightly increased. When dry the plate is ready to be varnished.

Varnishing.—The collodion film being very delicate and easily scratched it is necessary to give it some hard protective coating. This is usually a resin dissolved in spirit. This varnish may either be purchased ready for use, or it can be manufactured by dissolving one pound of seed lac in a gallon of methylated spirits. It will require keeping several days in a warm place before it is all dissolved. It must also be well shaken every now and then. When it is quite dissolved the solution is decantered off and filtered. Other methods of making varnish will be found described under that heading.

To coat the plate with varnish heat the former to a blood heat, and apply the varnish in the same manner as described for coating the plate with the collodion. When the superfluous

varnish is drained off into another bottle rest the lower edge of the plate upon blotting paper to remove any drops of the varnish. The plate is then heated till the back becomes uncomfortably hot. A good method of heating the plate is by moving it briskly over a lamp chimney or a Bunsen burner. It must not, however, be placed near enough for the solvent of the varnish to catch fire. If amber varnish be used it must be applied cold.

The negative is then ready for the printing operations.

COLLODION WET PROCESS FOR POSITIVES.—Very little difference in the manipulation is necessary for the production of positives by the wet process than for negatives as described under **Collodion Wet Process.** The chief object is to obtain the deposit of silver as white as possible. The collodion is the same as that recommended for the production of negatives. The silver bath should be weaker. A good formula is:

Silver nitrate (recrystallized)	250 grains
Nitric acid	½ minim
Water	10 ounces

For development the pyrogallic developer recommended for negatives can be used. Abney recommends the following:

Ferrous nitrate	110 grains
Ferrous sulphate	60 grains
Nitric acid	20 minims
Alcohol	quant. suf.
Water	4 ounces

The ferrous nitrate may be prepared by taking barium nitrate 130.5 grains, and dissolving it in two ounces of water. A solution of 76 grains of ferrous sulphate, dissolved in two ounces of water, is next added to it. A precipitate of barium sulphate falls. This must be filtered out, and 110 grains of ferrous nitrate are left in solution. The nitric acid should be dropped in, diluted with half-an-ounce of water. The alcohol is added after the 60 grains of sulphate of iron have been dissolved. The effect of the nitric acid is to cause the silver to deposit with a white lustre by reflected light. The exposure required is less than for a negative. The cyanide fixing solution should be used. As soon as dry the film side is varnished with a black varnish. The image is then seen from the back in its proper position. A receipt for a good black varnish will be found under **Varnish.**

Instead of glass, ferrotype plates may be used. These are thin iron plates enamelled with black or chocolate-brown enamel. They are first cleaned by the application of a little dilute potash or dilute nitric acid, and finally washed in distilled water, and polished with a silk handkerchief. They are then coated with collodion, sensitized, exposed, developed and fixed in the manner described. The dried picture only requires to be coated with a protected transparent varnish. It must be remembered, however, that with positives of this kind the image is reversed.

COLLOGRAPHIC PROCESSES.—Under collographic methods of photo-mechanical printing may be classed such processes as collotype, heliotype, etc. These processes are analogous in principle, but vary considerably in detail. They are fully described under their respective headings.

COLLOIDS.—This name was given by Graham to those non-crystalline substances which do not diffuse through porous membranes. The chief organic colloids are cellulose, gum, starch, dextrine, tannin, gelatine, caramel and albumen. The inorganic colloids are hydrated oxides of iron, hydrated silica, alumina, chromium, etc.

COLLOTYPE.—A photo-mechanical printing process based upon the fact that if a film of bichromated gelatine be dried at a moderately high temperature and exposed under a negative, it may, when washed and dried, be treated in the same manner as a lithographic stone, to which it shows similar properties—that is to say, it will absorb water and refuse greasy ink in some parts, whilst in others it will refuse water and take up the ink. The discovery of this property was made by Fox Talbot in 1853. His researches were followed up by Poitevin. For the first practical process of collotype we are, however, indebted to Tessie de Motey, who used a copper-plate to support the gelatine film, and potassium bichromate as the reducing agent. The present perfect method of collotype printing is, however, due to the labors of Albert, Husnik and Obernetter, who worked hard to surmount the innumerable difficulties which first arose.

The process of collatype is now very largely used in nearly all countries, and is worked under various names. In Germany chiefly as lichtdruck; in France as phototypie, and in England as collotype, phototype, albertype, and various other fancy names. It may be briefly described as follows: A thick piece of plate glass is carefully ground with fine emery or silicia powder. It is then coated with a mixture of white of egg and silicate of soda. After rinsing in water and drying, it is warmed and coated with a thin film of dichromatized gelatine, and allowed to again dry in a suitable heating apparatus. When dry, the plate is placed under a reversed

negative and exposed to light. The back of the film is also given a slight exposure. It is then laid in cold water, and the dichromate thoroughly removed from the film. The plate is then allowed to dry, after which operation it is first soaked in cold water, and afterwards in a mixture of glycerine and water. It is then ready for the printing press. When in the printing press, the plate has to be kept well moistened with glycerine and water. The effect of this is to cause the unexposed parts of the gelatine film to swell, and upon this property of bichromatized gelatine the process of collotype is based.

Preparing the Plate.—The following is a more detailed description of the process: Some sheets of thick British plate glass, at least one-fourth inch in thickness, are first procured, somewhat larger than the size of the picture. For small sizes a margin of three inches outside the picture should be given, while for larger sizes it is well to have a margin of from four to six inches. The glass selected should be quite free from scratches or other defects, and should have its edges well rounded for convenience and safety in handling. These sheets of glass are intended as supports for the collotype image, and have now to be ground true. This operation is performed by first laying one sheet of glass upon a firm support, dusting it over with the finest emery powder, sprinkling it with water, and then laying another sheet of glass over it. The upper sheet of glass is then moved in every possible direction, a circular motion being kept up as far as possible. The underneath plate should be repeatedly supplied with the emery powder and water until the two plates have been evenly ground all over. This is easily seen by washing away the emery powder. The presence of shiny or unground parts is at once detected, and the grinding process must be proceeded with. To assist in the moving of the top plate glass a pneumatic holder, or, better still, two of them, will be found very serviceable to obtain a better hold of the plate. The grinding of the glass in this manner ensures a perfect flat surface. It also causes the chromated gelatine to adhere with greater tenacity, and assist in the formation of the necessary grain in the case of thin layers.

After grinding, the plate is well washed and freed from the emery powder. It is then flooded with—

Liquid ammonia	1 ounce
Alcohol	1 ounce
Water	5 ounces

It is then well washed with clean water and coated with the substratum of albumen and water-glass. The formula is—

Distilled water	4 ounces
White of egg (whisked)	3 ounces
Silicate of soda	1 ounce

This should be well beaten up into a froth, and placed in a bottle containing some pieces of broken glass. Here it is allowed to settle for five or six hours, when it is filtered. The wet plate is covered over with this two or three times, and placed in a rack to dry in a warm current of air.

Instead of albumen stale beer is sometimes used, to which caustic potash has been added until it ceases to show an acid reaction if tested with blue litmus paper.

The most careful attention must be paid to the filtration of the substratum, and to the even coating and drying in a clean place quite free from dust.

The next operation is the coating of the plate with dichromatized gelatine. This is the most important part, and on it rests the success of the whole of the subsequent operations. The principal points to be observed are that the exact quantity only of the solution be allowed to remain on the plate, and that this quantity be evenly distributed over the surface.

The gelatine sensitive solution is made up by first soaking 2 ounces of Nelson's gelatine No. 2, and one-half ounce of Nelson's No. 1, in 30 ounces of water, to which 10 drops of a saturated solution of chrome alum have been added. When quite soft it is heated to a temperature of 125 degs. to 150 degs Fahr., when the gelatine will have dissolved. Then add, with constant stirring, 150 grains of finely-powdered potassium dichromate. The solution is then well stirred up and drained through muslin, or Japanese filter paper, into a suitable porcelain jar. If kept in a cool place it may be used as required. The ground glass plates which have been washed and treated with the substratum as described are placed in a warm drying box, and then levelled on a levelling stand. Sufficient quantity of the dichromatized gelatine is then dissolved and strained into a warm glass beaker thoroughly clean. Out of this the solution is poured on to the plate balanced on the palm of the left hand. The plate is then inclined in different directions until the solution has been made to run all over it. Air-bubbles and other imperfections are removed, and the plate returned to the level in the drying box. The box is then closed, and the heat gradually increased to a temperature of about 120 degs. Fahr. A drying box for this purpose is described elsewhere. It is important that a current of air freely circulates in all parts of the box, and also that the flow is constant. If any fluctuation in the current or in the temperature take place, the plates will dry unevenly and unsafe for use.

If kept at an even temperature of 120 degs. Fahr., the plates should take about two or three hours to dry. At this period they are removed or allowed to remain in the box to cool gradually,

the source of heat being extinguished, and should have a fine even matt surface. If there is any appearance of gloss over the whole or part of the film, the gelatine is too hard, and requires the addition of a small quantity of parchment size.

Instead of gelatine, isinglass is used by some workers. The following formula is given in Dr. Schnauss' valuable treatise upon this subject*: Two grammes of the best Russian isinglass are cut up into the smallest possible pieces with a pair of sharp scissors. soaked in 25 c.c. of water for twelve hours, heated nearly to boiling point until solution is effected, and then filtered while hot through close flannel. Cover six grammes of good collotype gelatine with 50 c.c. of water and allow to stand. Heat nearly to boiling point and thoroughly incorporate the two solutions; again while hot filter through paper or close flannel. To this add 11 c.c. of a filtered solution (1.8) of ammonium dichromate. The solution is then heated to 50 degs. C., and the plates warmed, coated and dried in the manner described with the previous solution given.

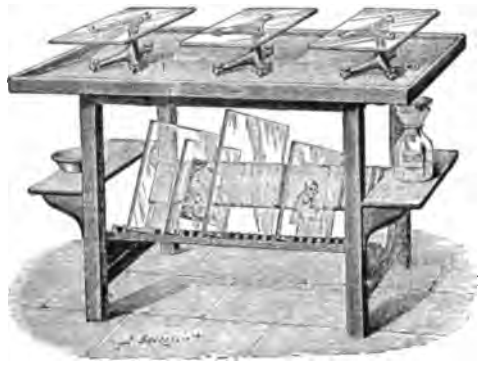


FIG. 136.—COLLOTYPE PLATE PREPARATION TABLE.

When the plates are dry it is not necessary to use them at once, but they may be kept in a cool, dry and dark place for several days. Some operators prefer to use a plate two or three days old.

The next process is the exposure to light of the plate under a negative. By a careful perusal of the subsequent operation the reader will see that if an ordinary negative be used a reversed picture would be the result. For some purposes this is of little matter, and an ordinary negative may be used. In the majority of cases, however, the reversal of the image would be a serious matter, and it is therefore necessary to prevent this by reversing the negative. There are many methods of doing this, any of which may be employed. One method is to strip the negative from the glass and reverse it in the printing frame. Another is to make the negative from a mirror, instead of directly from the object. The negative films now in the market are very convenient, as it is only necessary to print with the back in contact with the plate. For detailed methods of reversing negatives see **Reversed Negative.**

The exposure to light will, of course, vary with the density of the negative and actinicity of the light. The best negatives are those which show a fine gradation between the shadows and high-lights. The negative is placed in an ordinary printing frame and the collotype placed face downwards upon it. The back is then put in and the frame closed. The exposure should be continued until the image is well defined upon the gelatine film. This can easily be seen by opening one-half of the back of the printing-frame in the dark room. Some operators, however, prefer to use an actinometer. Dr. Schnauss recommends the printing of half-tone plates in diffused light.

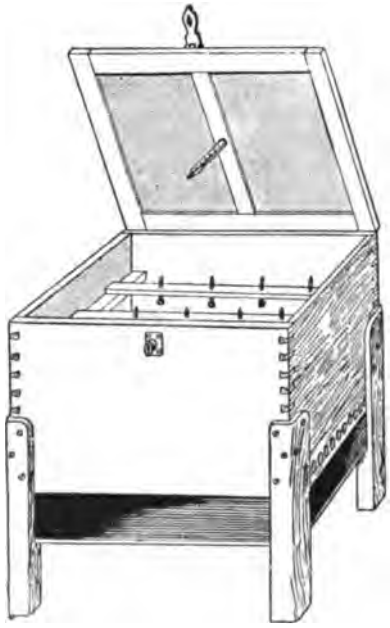


FIG. 137.—COLLOTYPE DRYING OVEN.

The accurate judging of the right exposure is not an easy, although an important matter. The greater the quantity of dichromate contained in the film, the shorter the necessary exposure. It may also be noted that a thin layer will require less exposure than a thicker one. In very dark weather many hours would be required, but in direct sunlight a few minutes would perhaps suffice.

Before printing it is a good practice to "mask" the negative by forming a margin at least an inch wide round the four sides of it. This may be accomplished either by painting with Indian ink or attaching strips of thin black paper or tinfoil.

After exposure under the negative the printing-frame is laid on a piece of black velvet on a table in the light, the back removed, and the back of the film exposed for from five to ten minutes to the light (not sunlight) in order to harden the back of the print. This should be done without disturbing the positions of the collotype plate or the negative.

The plate is next removed from the printing-frame, and immersed in clear cold water for from six to eight hours, changing the water every now and then. This will remove the dichromate from the film and leave the picture only visible as a slight brown image. The film of the plate is then hardened by soaking for about fifteen minutes in a one per cent. solution of alum. The plate is then given a final wash and placed aside for two or three days to dry.

It is then ready for putting in the press and printing from.

* "Collotype and Photo-Lithography," Iliffe & Son.

Printing.—The printing from collotype is usually done in an ordinary typographic press, but many finely constructed steam machines are now made for this purpose, notably by Alauzet & Co., of Paris, and Koch, of Leipzig. These differ but little from the ordinary lithographic presses, and an output of between 1,000 to 1,500 copies per day can be obtained with them.

The back of the plate is first cleaned and then immersed in the etching or damping solution—

Water	5 parts
Liq. ammonia	1 part
Glycerine	3 parts
Nitrate of lime	$\frac{1}{10}$ part

Dilute when required for use with 150 parts of water.

In this solution the plates may remain for an hour or so. Instead of the one given the following may be used:

Glycerine	5 ounces
Water	10 ounces
Sodium chloride	30 grains

The next operation is the fixing of the collotype plate in the bed of the press. The plate is removed from the etching solution and fixed by adhesion to the bed of glass or polished iron plate. Another method is to spread some fine plaster of Paris over the bed of the press, made into a cream with water, and lay the dry collotype plate on it. It is then well pressed down in a level position, and the plate flooded with one of the etching solutions given.

A piece of the best chalk ink is next taken with a spatula, and spread upon the inking slab of the machine. A small quantity of refined middle varnish, one drop of olive oil, and one or two drops of the best French turpentine are then added, and the whole well mixed up with the palette knife. The usual methods of distributing the ink and rolling up are then carried out. The printing plate should have been well secured, and the moistened surface evenly dried with a roller covered over with fine quality wash leather. The inky roller is passed over the plate with light pressure several times, and rolled backwards and forwards until the ink is evenly and perfectly distributed over the surface of the plate. If it be rolled slowly, with pressure applied, ink deposits itself upon the plate, but if rolled quickly and lightly, it removes the ink from the print layer. The most careful collotype printers use two rollers, one of leather, and a smoother roller of glue composition, which is applied after the other, and serves to considerably improve the half tones.

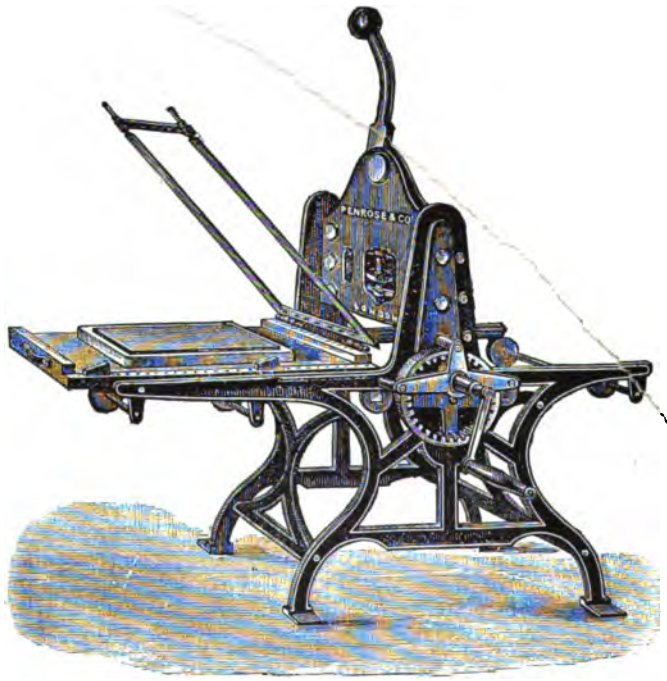


FIG. 138.—HAND PRESS FOR COLLOTYPE PRINTING.

When the plate is properly inked the frame of the press is brought down into position, and the paper adjusted over the mask. With regard to the quality of the paper, it should be good and well sized; a most suitable paper is that known as dull enamel. In France and Germany a paper prepared with a pink or other tinted chalk is used. It is largely manufactured in Germany, and sold as Kreide Papier. It has a dull enamel surface, and its tint gives a pleasing effect to many subjects. A good collotype printed upon this paper and varnished would be taken by many for a silver print.

After the paper is laid on it is backed with a few pieces of smooth paper, and covered with a tympan attached to its frame. The bed of the press is then pushed under the scraper, and the latter regulated to give sufficient pressure.

After the pressure is applied the paper is carefully lifted up from the printing surface, to which it will slightly adhere. After each impression the plate is damped with the damping solution applied with a sponge, and blotted off with a clean piece of plate paper, otherwise the whites will become tinted. With some plates the application of the damping solution will not be necessary so often.

The practice of printing from a collotype plate is only one that can be acquired by

constant perseverance and application of hand and mind. No further description of any practical use could be given here.

After printing from the plate it may be cleaned with a little turpentine, which will remove all the ink, and after its evaporation the damping solution is removed by washing in water, and the plate dried and kept for future use in a cool place.

We must now turn our attention to the collotype prints pulled from the plate. They very often contain little white spots or other imperfections, which can be touched up with a finely-pointed camel-hair brush and a little of the printing ink thinned with turpentine. Any finger marks or ink stains upon the white margins of the prints can be removed with an indiarubber ink eraser.

The prints can next be mounted and rolled or burnished.

If the prints are upon sized paper they may be varnished with a varnish of white lac dissolved in wood naphtha in the proportions 1 to 6, and filtered. This varnish is best applied with a piece of soft flannel made in the form of a dabber. If the prints have not been made upon sized paper it will be necessary before varnishing to brush them over with a 10 per cent. solution of gelatine applied with a broad camel-hair brush.

Another method given in Dr. Schnauss' book by which sizing may be avoided is to dip each picture, after drying into the following solution:

Water	500 c.c.m.
Borax	130 grammes
White shellac	100 grammes
Sodium	6 grammes

Both the borax and the carbonate are dissolved in boiling water, and the powdered shellac added in small quantities. When solution is completed it is carefully filled and allowed to cool. The impressions are placed two and two back to back on a frame and dipped into the varnish, which gives them a shellac coating. To unite, the solution must be kept at a temperature of between 15 deg. and 20 deg. C.

The enamel paper referred to is best done with an alkaline solution of shellac, which can be prepared by dissolving eight ounces of powdered bleached shellac in a quart of alcohol and a quart of ammonia liq. fort. After solution three pints of hot water are added, the whole allowed to cool, and then filtered. It is applied to the prints with a piece of flannel or a Blanchard brush.

When perfectly dry mounted prints may be burnished or rolled.

COLLOTYPE, COLOURED.—A method of collotype printing in colors has been worked for some time in Germany A number of negatives are made according to the number of different colors required. A collotype plate is then made from each negative, having all its parts blocked out except those parts required to be printed of that color. The printing is then done as in chromo-lithography, the prints being printed from all the plates and kept into position by a suitable arrangement.

COLOPHONY.—A black resin, the solid residuum of the distillation of turpentine after the oil has been worked off.

COLOR.—See **Light** and **Optics.**

COLOR BLINDNESS.—Also known as **Daltonism**, after the chemist Dalton, who labored under this infirmity of the human eye, by which it fails to distinguish certain colors. The vision of a color-blind person may be perfect with regard to distinguishing the form of bodies, but different colors, such as red and green, are totally indistinguishable. Some persons see everything either to be light or dark, and have no conception of any other colors. This, however, is rare. It is usually the primary or secondary colors which cannot be distinguished from each other.

COLORED PHOTOGRAPHS.—By colored photographs is meant the production of photographs colored by artificial means, and not the making of photographs in natural colors—a process not yet accomplished except by very unsatisfactory means.

There are various methods of coloring photographs which may briefly be divided under two headings—the application of color to the surface of the print, and its application behind the photographic image. The art of harmoniously coloring photographs is one that is only acquired by practice and natural artistic abilities. Many text-books upon the subject have been published, which the beginner should study to become acquainted with the mechanical part of the art.

The process of coloring at the back was one that was adopted with the old alabrastine process, and a "penetrating varnish" was used which had the effect of rendering the colors visible upon the contrary side.

The late W. B. Woodbury invented a method of producing colored photographs, or photochromographs as they were called. Photographic prints produced by the Woodburytype were transferred to paper supports previously painted or colored with the necessary pigments, which, seen through the thin film containing the image, possessed the appearance of colored photo-

graphs, and in many cases closely resembled delicate oil paintings. A similar effect can be produced by the carbon process.

Another method of producing colored photographs with very delicate effects is by fixing a paper photograph upon a cushion shaped glass with transparent cement. When this is dry, two thirds of the paper support of the photograph are rubbed away with sand-paper, and the remaining part made transparent with melted paraffin wax. Transparent colors are then applied, which appear very soft when viewed from the front. A second coating of paraffin wax is then applied, and the heavier colors laid on. Another layer of wax is then applied as a protective coat.

Carbon prints may be colored with oil, water, or powder colors. Before coloring with oil colors, the print should be sized with a solution of isinglass dissolved in equal parts of hot water and spirits of wine.

COLORED SENSITIZING.—A process employed in orthochromatic photography in which the gelatine plate is sensitized with a dye of some kind, which has the effect of causing the plate to give a truer representation of the color value of the image. See **Orthochromatic Photography.**

COLORIMETER.—An instrument for measuring the color of a liquid. In the volumetric estimation of silver with potassium chromate it is very often a difficult matter to make a proper and correct test owing to the original yellow color of the solution itself. A colorimeter introduced by Dupré interposes between the eye and the test liquid a flat glass cell (of which the faces are about half an inch apart) containing a solution of potassium chromate of such strength as will neutralise the color of the test liquid, which thus appears colorless, and in which the faintest tinge of red formed by the silver chromate is easily visible.

COLOR SCREEN.—A colored screen used in the process of orthochromatic photography, *q. v.*

COLOR-SENSITIVE PLATES.—See **Orthochromatic Process.**

COLOR-SENSITIVE PROCESS.—See **Orthochromatic Process.**

COLOR TEST FOR EMULSIONS.—See **Emulsion.**

COLZA OIL.—A non-drying oil obtained from the seeds of *Brassica napus.* Pure colza oil is comparatively inodorous, has a specific gravity of 0.9,128 at 60 degs. Fahr., and solidifies at 20 degs. Fahr. It is an excellent lubricant for machinery, and was formerly much used for lighting purposes.

COMBINATION, CHEMICAL.—Chemical combination is governed by certain laws. In chemistry we have two kinds of matter, *i.e.*. elements and compounds. Elements can only undergo chemical change by combining with other elements or compounds, but compounds can combine with elements or other compounds, and can also be separated into two or more compounds each unlike the others, and each weighing less than the original quantity of the compound used (Watts).

The laws of chemical combination are as follows (Watts's "Dictionary of Chemistry," 1889):

Law of Constant Proportions.—The masses of the constituent elements of every compound stand in an unalterable ratio to each other, and also to the mass of compound formed.

Law of Multiple Proportions.—When two elements combine to form more than one compound, the masses of one of the elements which combine with a constant mass of the other element bear a simple relation to each other.

Law of Reciprocal Proportions, or Law of Combining Weights.—The masses of different elements which severally combine with one and the same mass of another element are also the masses of these different elements which combine with each other, or they bear a simple relation to these masses. See also **Chemistry.**

COMBINATION PRINTING.—A method of printing in which the whole or portions of two or more negatives are combined.

COMBINED TONING AND FIXING SOLUTIONS.—See **Toning.**

COMBINING WEIGHTS.—See **Elements.**

COMBUSTION.—Chemical combination. Chemical action producing the sensation of heat and sometimes light.

COMETS.—Peculiar defective markings which make their appearance upon gelatine plates, and which have the form of a comet. (See **Dry Plates.**)

COMMERCIAL ACETIC ACID.—See **Acetic Acid.**

COMMON SALT.—See **Sodium Chloride.**

COMPARATIVE EXPOSURE.—For comparative exposures with the different stops see **Diaphragm** and **Exposure.**

COMPENSATOR.—With all images given by lenses there is a gradual decrease in brightness from the centre of the field to the margin. This is especially noticeable with short focus lenses used as wide angle lenses on a large plate. Many methods have been proposed to compensate for this difference in the illumination. The one most practicable is that recommended by D. Miethe.* This apparatus consists of two extremely thin glasses, one of them being plano-convex and made of smoky glass, the other plano-concave and of equal curvature, and made of plain crystal glass. The two together form a parallel plane. Fig. 139 illustrates the apparatus. The glass plate when properly mounted and attached in front or back of the objective lens will, when the smoky glass has been properly selected, depress the centre rays to equal the intensity of those passing through the margin. To attach the compensator to the wide angle lens it becomes necessary to measure the distance from the stop plane to the poles of either the anterior or posterior lens and to have the diameter of the compensator form the basis of a cone projecting from the centre of the stop as shown in the diagram. In this diagram the thickness of the compensator is exaggerated for the sake of distinctiveness. Of course by the use of this arrangement the exposure is much increased.

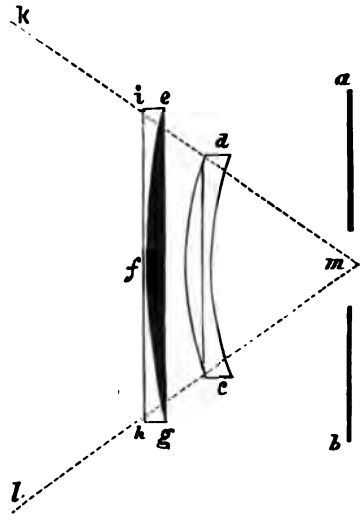


FIG. 139.—COMPENSATOR.

COMPLEMENTARY COLORS.—See **Light and Optics.**

COMPOSITE PORTRAIT.—A process of obtaining a normal or average type of the features of a number of individuals, either by photographing one over the other upon the same plate, or making one print from a number of negatives.† Some peculiar effects have thus been obtained; for instance, photographs of a father and mother have been combined showing a striking likeness to some of the children. Film negatives are best for this purpose,‡ as they can be laid one upon the other and a print made from the whole.

COMPOUND.—Anything which is composed or compounded of two or more elements or parts—a combination.

COMPOUND CONDENSER.—See **Condenser.**

COMPOUND MICROSCOPE.—A microscope made with a combination of lenses.

COMPOUND PRISM.—A prism formed by several prisms being cemented together one over the other, base to apex.

COMPOUND RADICAL.—A chemical term given to a radical which operates as if it were an element, while it is in reality composed of two or more elements.

COMPOUND SPIRITS.—Rectified spirits to which other ingredients have been added.

CONCAVE.—In optics, a lens hollow or depressed in the center. There are three kinds —(1.) Plano-concave, in which one side is plane or flat and the other hollowed out. (2.) Concavo-convex, in which one side is concave or hollowed out and the other side is raised or convex. (3.) A double concave, bi-concave, or concavo-concave, in which both sides are hollow or concave.

CONCAVO-CONCAVE.—See **Bi-concave.**

CONCAVO-CONVEX.—Concave on one side and convex on the other.

CONCAVO-PLANE.—See **Plano-concave.**

CONCENTRATED SOLUTION.—A solution prepared by concentration, a process which has for its object to increase the amount of a dissolved substance in a liquid relatively to the quantity of the solvent, without adding any more of the dissolved substance itself. When the solvent is volatile, this object is effected by evaporation, as when water, alcohol or ether is expelled from a solution by heat, by exposure to the air, or *in vacuo.* If the dissolved substance is more volatile than the solvent, the concentration is effected by distillation, the more concentrated liquid being then found in the distillate, as in the rectification of hydrated alcohol and of volatile oils dissolved in water. In the case of aqueous liquids concentration is sometimes effected by

* "American Annual of Photography," 1890.
† Mr. Francis Galton was the first to produce photographic composites.
‡ This idea was first suggested by W. Jerome Harrison.

freezing out the water; in this manner a solution of salt may be obtained from sea water, strong spirit from vinous liquids, etc. (Watts's Dict. Chem.)

CONCENTRIC LENS.—See **Lens.**

CONCHININE (Formula, $C_{20}H_{24}N_2O_2$).—Also known as Quinidine It is an organic base, isomeric with quinine, occurring in cinchona bark. It crystallizes in bitter colorless prisms, soluble in dilute sulphuric acid, the solution showing blue fluorescence. It is used in the manufacture of luminous paint (*q. v.*)

CONCOAGULATION—A coagulation of two or more bodies in a mass.

CONDENSATE—To condense—to compress into a close form.

CONDENSATION IN DENSITY.—The passage of gases or vapors to the liquid state, liquefaction. It may be produced by cooling, compression, or chemical affinity.

The reduction of a liquid to a smaller bulk, with proportionate increase in the specific gravity.

CONDENSER.—A lens which gathers the rays of light together and concentrates them upon one point. A compound condenser is a combination of two or more lenses having the same object. In photography the condenser is principally used for enlarging purposes, where it collects the rays of light and passes them through the negative or the positive, and brings them to a focus in the lens which projects the image. For further information upon the condenser see **Enlarging.**

CONDENSER FOR LIQUIDS.—A liquid condenser is an apparatus in which a coil of piping traverses a tub, which receives a constant accession of cold water, condensing the vapor in the coil. There is a great variety of these. Liebig's is one of the best for laboratory use.

CONDY'S FLUID.—A solution of manganate of sodium. It acts as a powerful and efficient disinfector by the oxidation of putrid matter. A quantity of it should occasionally be poured down bad-smelling drains. It also acts as a test for the purity of water. A few drops of the solution added to the water will, if any impure matter be present, turn the color of the water to a brownish hue.

CONE.—A term sometimes used in optics to denote a pencil of rays of light, emanating from a point, and diverging as they proceed on their course.

CONGELATION.—The passage of a body from the liquid to the solid state. This phenomenon is regulated by two known laws—(1) Every body under the same pressure solidifies at a fixed temperature, which is the same as that of fusion.* (2) From the commencement to the end of the solidification the temperature of a liquid remains constant.

There are some liquids, as ether, alcohol, etc., that have never been seen in a solidified state.

CONJUGATE FOCI.—A lens has two foci having a definite relation to each other, and are, therefore, termed the "conjugate foci." See **Focus.**

Besides the equivalent focus of the lens, which should be known by the worker, it is often useful to know—1st, the size of the image that will be obtained; 2d, the distance between the object and the camera; 3d, the size of the object to be photographed; and 4th, the distance of the focusing screen from the center of the lens. All this information can be obtained from the following table of conjugate foci, compiled from Suter's metrical tables by Mr. J. R. Gotz.

To explain the table, the top line of Table I. contains the equivalent foci of different lenses from 3 to 36 inches, and the relative proportions of the images and the object itself are given in the vertical column at the left hand side. The other figures are the distance that the object is from the lens, and the distance of the lens from the ground glass focusing screen.

If it is required to reduce with a lens of a given focal length, follow the horizontal line from the figure denoting the proportion required until the column headed by the equivalent focus of the lens used. If the tables be reversed they may be used for enlargement.

Table II. gives the approximate sizes of the image of a figure of a man 5 feet 9 inches from life size to a reduction of $\frac{1}{300}$. As an example, a head 3 inches would be a third of its natural size (taken at 9 inches). If a lens at 15-inch focus be used it will, according to the table, require a distance of 5 feet, the posterior focal distance being 20 inches.

Another instance of the use of a table of this kind: If a building, say, 25 feet high and 25 feet wide, is to be taken at a distance of 40 feet with a 6-inch lens, the reduction will be, according to the table, $\frac{1}{80}$, and the image will, therefore, occupy about 4½ inches horizontally and 3 inches vertically, and would require a half-plate camera to get a good picture.

* Some fats are exceptions to this rule.

TABLE I.—FOR EQUIVALENT FOCI FROM 3IN. TO 5IN.

Relative Proportion of Image.	3	3¼	3½	3¾	4	4¼	4½	4¾	5
1/1	0 6 ..	0 6½ ..	0 7 ..	0 7½ ..	0 8 ..	0 8½ ..	0 9 ..	0 9½ ..	0 10
	0 6 ..	0 6½ ..	0 7 ..	0 7½ ..	0 8 ..	0 8½ ..	0 9 ..	0 9½ ..	0 10
1/2	0 9 ..	0 9¾ ..	0 10½ ..	0 11¼ ..	0 12 ..	0 12¾ ..	0 13½ ..	0 14¼ ..	0 15
	0 4½ ..	0 4⅞ ..	0 5¼ ..	0 5⅝ ..	0 6 ..	0 6⅜ ..	0 6¾ ..	0 7⅛ ..	0 7½
1/3	1 0 ..	1 1 ..	1 2 ..	1 3 ..	1 4 ..	1 5 ..	1 6 ..	1 7 ..	1 8
	0 4 ..	0 4¼ ..	0 4 10/16 ..	0 5 ..	0 5 5/16 ..	0 5 11/16 ..	0 6 ..	0 6 5/16 ..	0 6 11/16
1/4	1 3 ..	1 4¼ ..	1 5½ ..	1 6¾ ..	1 8 ..	1 9¼ ..	1 10½ ..	1 11¾ ..	2 1
	0 3¾ ..	0 4 1/16 ..	0 4⅜ ..	0 4 5/8 ..	0 5 ..	0 5 5/16 ..	0 5 5/8 ..	0 5 15/16 ..	0 6¼
1/5	1 6 ..	1 7½ ..	1 9 ..	1 10⅝ ..	2 0 ..	2 1½ ..	2 3 ..	2 4½ ..	2 6
	0 3 9/16 ..	0 3⅞ ..	0 4¼ ..	0 4½ ..	0 4 12/16 ..	0 5⅛ ..	0 5⅜ ..	0 5¾ ..	0 6
1/6	1 9 ..	1 10¾ ..	2 0½ ..	2 2¼ ..	2 4 ..	2 5¾ ..	2 7½ ..	2 9¼ ..	2 11
	0 3½ ..	0 3¾ ..	0 4⅛ ..	0 4⅜ ..	0 4 11/16 ..	0 4 15/16 ..	0 5¼ ..	0 5 9/16 ..	0 5 13/16
1/7	2 0 ..	2 2 ..	2 4 ..	2 6 ..	2 8 ..	2 10 ..	3 0 ..	3 2 ..	3 4
	0 3 7/16 ..	0 3⅝ ..	0 4 ..	0 4¼ ..	0 4 9/16 ..	0 4⅞ ..	0 5⅛ ..	0 5⅜ ..	0 5 11/16
1/8	2 3 ..	2 5¼ ..	2 7½ ..	2 9¾ ..	3 0 ..	3 2¼ ..	3 4½ ..	3 6¾ ..	3 9
	0 3⅜ ..	0 3 10/16 ..	0 3 12/16 ..	0 4 8/16 ..	0 4½ ..	0 4¾ ..	0 5 1/16 ..	0 5 5/16 ..	0 5⅝
1/9	2 6 ..	2 8½ ..	2 11 ..	3 1½ ..	3 4 ..	3 6½ ..	3 9 ..	3 11½ ..	4 2
	0 3 5/16 ..	0 3 9/16 ..	0 3⅞ ..	0 4 1/16 ..	0 4 7/16 ..	0 4 11/16 ..	0 5 ..	0 5¼ ..	0 5⅝
1/10	2 9 ..	2 11¾ ..	3 2½ ..	3 5¼ ..	3 8 ..	3 10¾ ..	4 1½ ..	4 4¼ ..	4 7
	0 3 5/16 ..	0 3½ ..	0 3 12/16 ..	0 4⅛ ..	0 4⅜ ..	0 4⅝ ..	0 4 12/16 ..	0 5 1/16 ..	0 5½
1/12	3 3 ..	3 6¼ ..	3 9½ ..	4 0¾ ..	4 4 ..	4 7¼ ..	4 10½ ..	5 1¾ ..	5 5
	0 3¼ ..	0 3½ ..	0 3 12/16 ..	0 4 1/16 ..	0 4⅜ ..	0 4 9/16 ..	0 4⅞ ..	0 5⅛ ..	0 5⅜
1/14	3 9 ..	4 0¾ ..	4 4½ ..	4 8¼ ..	5 0 ..	5 3¾ ..	5 7½ ..	5 11¼ ..	6 3
	0 3 5/16 ..	0 3 7/16 ..	0 3¾ ..	0 4 ..	0 4¼ ..	0 4 9/16 ..	0 4 13/16 ..	0 5 1/16 ..	0 5⅜
1/16	4 3 ..	4 7¼ ..	4 11½ ..	5 3¾ ..	5 8 ..	6 0¼ ..	6 4½ ..	6 8¾ ..	7 1
	0 3 5/16 ..	0 3 7/16 ..	0 3¾ ..	0 4 ..	0 4¼ ..	0 4½ ..	0 4¾ ..	0 5 1/16 ..	0 5 5/16
1/18	4 9 ..	5 1¾ ..	5 3½ ..	5 11¼ ..	6 4 ..	6 8¾ ..	7 1½ ..	7 6¼ ..	7 11
	0 3 5/16 ..	0 3 7/16 ..	0 3 11/16 ..	0 3 15/16 ..	0 4¼ ..	0 4½ ..	0 4¾ ..	0 5 ..	0 5 5/16
1/20	5 3 ..	5 8¼ ..	6 1½ ..	6 6¾ ..	7 0 ..	7 5¼ ..	7 10½ ..	8 3¾ ..	8 9
	0 3⅛ ..	0 3⅜ ..	0 3 11/16 ..	0 3 15/16 ..	0 4 5/16 ..	0 4 7/16 ..	0 4 11/16 ..	0 5 ..	0 5¼
1/24	6 3 ..	6 9¼ ..	7 3½ ..	7 9¾ ..	8 4 ..	8 10¼ ..	9 4½ ..	9 10¾ ..	10 5
	0 3⅛ ..	0 3⅜ ..	0 3⅝ ..	0 3⅞ ..	0 4 5/16 ..	0 4⅜ ..	0 4 13/16 ..	0 5 ..	0 5¼
1/30	7 9 ..	8 4¾ ..	9 0½ ..	9 8¼ ..	10 4 ..	10 11⅝ ..	11 7½ ..	12 3¼ ..	12 11
	0 3⅛ ..	0 3⅜ ..	0 3 5/8 ..	0 3⅞ ..	0 4⅛ ..	0 4⅜ ..	0 4 5/8 ..	0 4⅞ ..	0 5 5/16
1/40	10 3 ..	11 1¼ ..	11 11⅛ ..	12 9¾ ..	13 8 ..	14 6¼ ..	15 4½ ..	16 2¾ ..	17 1
	0 3 1/16 ..	0 3 5/16 ..	0 3 9/16 ..	0 3 13/16 ..	0 4 1/16 ..	0 4 5/16 ..	0 4 9/16 ..	0 4 13/16 ..	0 5⅛
1/50	12 9 ..	13 9¾ ..	14 10½ ..	15 11¼ ..	17 0 ..	18 0¾ ..	19 1½ ..	20 2¼ ..	21 3
	0 3 1/16 ..	0 3 5/16 ..	0 3 9/16 ..	0 3 13/16 ..	0 4 1/16 ..	0 4 5/16 ..	0 4 9/16 ..	0 4 13/16 ..	0 5½
1/60	15 3 ..	16 6¼ ..	17 9½ ..	19 0¾ ..	20 4 ..	21 7¼ ..	22 10½ ..	24 1¾ ..	25 5
	0 3 1/16 ..	0 3 5/16 ..	0 3 9/16 ..	0 3 13/16 ..	0 4 1/16 ..	0 4 5/16 ..	0 4 9/16 ..	0 4 13/16 ..	0 5 1/16
1/80	20 3 ..	21 11¼ ..	23 7½ ..	25 3¾ ..	27 0 ..	28 8¼ ..	30 4½ ..	32 0¾ ..	33 9
	0 3 1/16 ..	0 3 5/16 ..	0 3 9/16 ..	0 3 13/16 ..	0 4 1/16 ..	0 4 5/16 ..	0 4 9/16 ..	0 4 13/16 ..	0 5 1/16
1/100	25 3 ..	27 4¼ ..	29 5½ ..	31 6¾ ..	33 8 ..	35 9¼ ..	37 10½ ..	39 11¾ .. 4	42 1
	0 3 ..	0 3¼ ..	0 3 9/16 ..	0 3 13/16 ..	0 4 1/16 ..	0 4 5/16 ..	0 4 9/16 ..	0 4 13/16 ..	0 5 1/16
1/120	30 3 ..	32 9¼ ..	34 3½ ..	37 9¾ ..	40 4 ..	42 10¼ ..	45 4½ ..	47 10¾ ..	50 5
	..	..	..	..	0 4 ..	0 4¼ ..	0 4½ ..	0 4¾ ..	0 5 1/16
1/150	37 9 ..	40 10¾ ..	44 0½ ..	47 2¼ ..	50 4 ..	53 5¾ ..	56 7½ ..	59 9¼ ..	62 11
	..	..	..	..	..	..	..	..	0 5
1/180	45 3 ..	49 0¼ ..	52 9½ ..	56 6¼ ..	60 4 ..	64 1¼ ..	67 10½ ..	71 7¾ ..	75 5
	..	..	..	..	..	..	..	..	
1/240	60 3 ..	65 3¼ ..	70 3½ ..	75 3¾ ..	80 4 ..	85 4¼ ..	90 4½ ..	95 4¾ ..	100 5
	..	..	..	..	..	..	..	..	
1/300	75 3 ..	81 6¼ ..	87 9½ ..	94 0¾ ..	100 4 ..	106 7¼ ..	112 10½ ..	119 1¾ ..	125 5
	..	..	..	..	..	..	..	..	

For Equivalent Foci From 5¼in. to 8½in.

Relative Proportion of Image.	5¼	5½	5¾	6	6½	7	7½	8	8½
1/1	0 10 1/16 ..	0 11 ..	0 11 1/2 ..	0 12 ..	0 13 ..	0 14 ..	0 15 ..	0 16 ..	0 17
	0 10 1/2 ..	0 11 ..	0 11 1/2 ..	0 12 ..	0 13 ..	0 14 ..	0 15 ..	0 16 ..	0 17
1/2	0 15 3/4 ..	0 16 1/2 ..	0 17 1/4 ..	0 18 ..	1 7 1/4 ..	1 9 ..	1 10 1/2 ..	2 0 ..	2 1 1/2
	0 7 7/8 ..	0 8 1/4 ..	0 8 5/8 ..	0 9 ..	0 9 3/4 ..	0 10 1/4 ..	0 11 1/4 .	1 0 ..	1 0 3/4
1/3	1 9 ..	1 10 ..	1 11 ..	2 0 ..	2 2 ..	2 4 ..	2 6 ..	2 8 ..	2 10
	0 7 ..	0 7 5/16 ..	0 7 5/8 ..	0 8 ..	0 8 5/8 ..	0 9 5/16 ..	0 10 ..	0 10 10/16 ..	0 11 5/16
1/4	2 2 1/4 ..	2 3 1/2 ..	2 4 3/4 .	2 6 ..	2 8 1/2 ..	2 11 ..	3 1 1/2 ..	3 4 ..	3 6 1/2
	0 6 7/16 ..	0 6 7/8 ..	0 7 5/16 ..	0 7 1/2 ..	0 8 1/8 ..	0 8 3/4 ..	0 9 3/8 .	0 10 ..	0 10 5/8
1/5	2 7 1/2 ..	2 9 ..	2 10 1/2 ..	3 0 ..	3 3 ..	3 6 ..	3 9 ..	4 0 ..	4 3
	0 6 8/16 ..	0 6 5/8 ..	0 6 7/8 ..	0 7 3/16 ..	0 7 3/4 ..	0 8 3/8 ..	0 9 ..	0 9 10/16 ..	0 10 8/16
1/6	3 0 3/4 ..	3 2 1/2 ..	3 4 1/4 ..	3 6 ..	3 9 1/2 ..	4 1 ..	4 4 1/2 ..	4 8 ..	4 11 1/2
	0 6 1/8 ..	0 6 7/16 ..	0 6 3/4 ..	0 7 ..	0 7 1/2 ..	0 8 8/16 ..	0 8 3/4 ..	0 9 5/16 ..	0 9 7/8
1/7	3 6 ..	3 8 ..	3 10 ..	4 0 ..	4 4 ..	4 8 ..	5 0 ..	5 4 ..	5 8
	0 6 ..	0 6 5/16 ..	0 6 9/16 ..	0 6 13/16 ..	0 7 3/8 ..	0 8 ..	0 8 8/16 ..	0 9 1/8 ..	0 9 11/16
1/8	3 11 1/4 ..	4 1 1/2 ..	4 3 3/4 ..	4 6 ..	4 10 1/2 ..	5 3 ..	5 7 1/2 ..	6 0 ..	6 4 1/2
	0 5 7/8 ..	0 6 3/16 ..	0 6 7/16 ..	0 6 3/4 ..	0 7 5/16 ..	0 7 3/8 .	0 8 7/16 ..	0 9 ..	0 9 11/16
1/9	4 4 1/2 ..	4 7 ..	4 9 1/2 ..	5 0 ..	5 5 ..	5 10 ..	6 3 ..	6 8 ..	7 1
	0 5 11/16 ..	0 6 1/8 ..	0 6 3/8 ..	0 6 11/16 ..	0 7 1/4 ..	0 7 3/4 .	0 8 3/8 ..	0 8 7/8 .	1 9 7/16
1/10	4 9 3/4 ..	5 0 1/2 ..	5 3 1/4 ..	5 6 ..	5 11 1/2 ..	6 5 ..	6 10 1/2 ..	7 4 ..	7 9 1/2
	0 5 3/4 ..	0 6 1/16 ..	0 6 5/16 ..	0 6 9/16 ..	0 7 5/16 ..	0 7 11/16 ..	0 8 1/4 ..	0 8 11/16 ..	0 9 5/8
1/12	5 8 1/4 ..	5 11 1/2 ..	6 2 3/4 ..	6 6 ..	7 0 1/2 ..	7 7 ..	8 1 1/2 ..	8 8 ..	9 2 1/2
	0 5 11/16 ..	0 5 15/16 ..	0 6 1/4 ..	0 6 1/2 ..	0 7 ..	0 7 9/16 ..	0 8 1/8 ..	0 8 13/16 ..	0 8 1/16
1/14	6 6 3/4 ..	6 10 1/2 ..	7 2 1/4 ..	7 6 ..	8 1 1/2 ..	8 9 ..	9 4 1/2 ..	10 0 ..	10 7 1/2
	0 5 5/8 ..	0 5 7/8 ..	6 0 5/16 ..	0 6 7/16 ..	0 6 15/16 ..	0 7 1/2 ..	0 8 ..	0 8 9/16 ..	0 9 1/8
1/16	7 5 1/4 ..	7 9 1/2 ..	8 1 3/4 ..	8 6 ..	9 2 1/2 ..	9 11 ..	10 7 1/2 ..	11 4 ..	12 0 1/2
	0 5 5/8 ..	0 5 7/8 ..	0 6 1/8 ..	0 6 3/8 ..	0 6 15/16 ..	0 7 7/16 ..	0 7 15/16 ..	0 8 1/2 ..	0 9 1/16
1/18	8 3 3/4 ..	8 8 1/2 ..	9 1 1/4 ..	9 6 ..	10 3 1/2 ..	11 1 ..	11 10 1/2 ..	12 8 ..	13 5 1/2
	0 5 9/16 ..	0 5 3/4 ..	6 0 1/16 ..	0 6 5/16 ..	0 6 7/8 ..	0 7 3/8 ..	0 7 7/8 ..	0 8 7/16 ..	0 9
1/20	9 2 1/4 ..	9 7 1/2 ..	10 0 3/4 ..	10 6 ..	11 4 1/2 ..	12 3 ..	13 1 1/2 ..	14 0 ..	14 10 1/2
	0 5 1/2 ..	0 5 3/4 ..	0 6 1/16 ..	0 6 5/16 ..	0 6 13/16 ..	0 7 3/8 ..	0 7 7/8 ..	0 8 3/8 ..	0 8 15/16
1/24	10 11 1/4 ..	11 5 1/2 ..	11 11 3/4 ..	12 6 ..	13 6 1/2 ..	14 7 ..	15 7 1/2 ..	16 8 ..	17 8 1/2
	0 5 1/2 ..	0 5 3/4 ..	0 6 ..	0 6 1/4 ..	0 6 3/4 ..	0 7 5/16 ..	0 7 3/4 ..	0 8 5/16 ..	0 8 7/8
1/30	13 6 3/4 ..	14 2 1/2 ..	14 10 1/4 ..	15 6 ..	16 9 1/2 ..	18 1 ..	19 4 1/2 ..	20 8 ..	21 11 1/2
	0 5 7/16 ..	0 5 11/16 ..	0 5 15/16 ..	0 6 3/16 ..	0 6 3/4 ..	0 7 1/4 ..	0 7 3/4 ..	0 8 1/4 ..	0 8 3/4
1/40	17 11 1/4 ..	18 9 1/2 ..	19 7 3/4 ..	20 6 ..	22 2 1/2 ..	23 11 ..	25 7 1/2 ..	27 4 ..	29 0 1/2
	0 5 3/8 ..	0 5 5/8 ..	0 5 7/8 ..	0 6 1/8 ..	0 6 5/8 ..	0 7 3/16 ..	0 7 11/16 ..	0 8 3/16 ..	0 8 11/16
1/50	22 3 3/4 ..	23 4 1/2 ..	24 5 1/4 ..	25 6 ..	27 7 1/2 ..	29 9 ..	31 10 1/2 ..	34 0 ..	36 1 1/2
	0 5 3/8 ..	0 5 5/8 ..	0 5 7/8 ..	0 6 1/8 ..	0 6 5/8 ..	0 7 3/16 ..	0 7 11/16 ..	0 8 1/8 ..	0 8 5/8
1/60	26 8 1/4 ..	27 11 1/2 ..	29 2 3/4 ..	30 6 ..	33 0 1/2 ..	35 7 ..	38 1 1/2 ..	40 8 ..	43 2 1/2
	0 5 1/16 ..	0 5 3/16 ..	0 5 5/16 ..	0 6 1/8 ..	0 6 5/8 ..	0 7 1/8 ..	0 7 5/8 ..	0 8 1/8 ..	0 8 5/8
1/80	35 5 1/4 ..	37 1 1/2 ..	38 9 3/4 .	40 6 ..	43 10 1/2 ..	47 3 .	50 7 1/2 ..	54 0 ..	57 4 1/2
	0 5 5/16 ..	0 5 9/16 ..	0 5 13/16 ..	0 6 1/16 ..	0 6 9/16 ..	0 7 1/16 ..	0 7 9/16 ..	0 8 1/8 ..	0 8 5/8
1/100	44 2 ..	46 3 1/2 ..	48 4 3/4 ..	50 6 ..	54 8 1/2 ..	58 11 ..	63 1 1/2 ..	67 4 ..	71 6 1/2
	0 5 5/16 ..	0 5 9/16 ..	0 5 13/16 ..	0 6 1/16 ..	0 6 9/16 ..	0 7 1/16 ..	0 7 9/16 ..	0 8 1/16 ..	0 8 1/16
1/120	52 11 1/4 ..	55 5 1/2 ..	57 11 3/4 .	60 6 ..	65 6 1/2 ..	70 7 ..	75 7 1/2 ..	80 8 ..	85 8 1/2
	0 5 5/16 .	0 5 9/16 ..	0 5 13/16 ..	0 6 1/16 ..	0 6 9/16 ..	0 7 1/16 ..	0 7 9/16 ..	0 8 1/16 ..	0 8 9/16
1/150	66 0 3/4 ..	69 2 1/2 ..	72 4 1/4 ..	75 6 ..	81 9 1/2 ..	88 1 ..	94 4 1/2 ..	100 8 .	106 11 1/2
	0 5 1/4 ..	0 5 1/2 ..	0 5 3/4 ..	0 6 1/16 ..	0 6 9/16 ..	0 7 1/16 ..	0 7 9/16 ..	0 8 1/16 ..	0 8 9/16
1/180	79 2 1/4 ..	82 11 1/2 ..	86 8 3/4 ..	90 6 ..	98 0 1/2 ..	105 7 ..	113 1 1/2 ..	120 8 ..	128 2 1/2
	..	..	..	0 6 ..	0 6 1/2 ..	0 7 1/16 ..	0 7 1/16 ..	0 8 1/16 ..	0 8 9/16
1/240	105 5 1/4 ..	110 5 1/2 ..	115 5 3/4 ..	120 6 ..	130 6 1/2 ..	140 7 ..	150 7 1/2 ..	160 8 ..	170 8 1/2
	..	..	..	..	..	0 7 ..	0 7 1/2 ..	0 8 ..	0 8 1/2
1/300	131 8 1/4 ..	137 11 1/2 ..	144 2 3/4 ..	150 6 ..	163 0 1/2 ..	175 7 ..	188 1 1/2 ..	200 8 ..	213 2 1/2
	..	..	..	..	..	..	..	..	

Table III.—For Equivalent Foci from 9in. to 14in.

Relative Proportion of Image.	9	9½	10	10½	11	11½	12	13	14
1/1	0 18 ..	1 7 ..	1 8 ..	1 9 ..	1 10 ..	1 11 ..	2 0 ..	2 2 ..	2 4
	0 18 ..	1 7 ..	1 8 ..	1 9 ..	1 10 ..	1 11 ..	2 0 ..	2 2 ..	2 4
1/2	2 3 ..	2 4½ ..	2 6 ..	2 7½ ..	2 9 ..	2 10½ ..	3 0 ..	3 3 ..	3 6
	1 1½ ..	1 2¼ ..	1 0 ..	1 3¾ ..	1 4½ ..	1 5¼ ..	1 6 ..	1 7½ ..	1 9
1/3	3 0 ..	3 2 ..	3 4 ..	3 6 ..	3 8 ..	3 10 ..	4 0 ..	4 4 ..	4 8
	1 0 ..	1 0 1/16 ..	1 1 5/16 ..	1 2 ..	1 2 1/16 ..	1 3 5/16 ..	1 4 ..	1 5 5/16 ..	1 6 1/16
1/4	3 9 ..	3 11½ ..	4 2 ..	4 4½ ..	4 7 ..	4 9½ ..	5 0 ..	5 5 ..	5 10
	0 11¼ ..	0 11⅞ ..	1 0½ ..	1 1⅛ ..	1 1¾ ..	1 2⅜ ..	1 3 ..	1 4¼ ..	1 5½
1/5	4 6 ..	4 9 .	5 0 ..	5 3 ..	5 6 ..	5 9 ..	6 0 ..	6 6 ..	7 0
	0 10 1/16 ..	0 11 7/16 ..	1 0 ..	1 0 10/16 ..	1 1 5/16 ..	1 1 13/16 ..	1 2 3/16 ..	1 3 5/16 ..	1 4 1/16
1/6	5 3 ..	5 6½ ..	5 10 ..	6 1½ ..	6 5 ..	6 8½ ..	7 0 ..	7 7 ..	8 2
	0 10½ ..	0 11⅛ ..	0 11 1/16 ..	1 0¼ ..	1 0 13/16 ..	1 1 7/16 ..	1 2 ..	1 3 5/16 ..	1 4 5/16
1/7	6 0 ..	6 4 ..	6 8 ..	7 0 ..	7 4 ..	7 8 ..	8 0 ..	8 8 ..	9 4
	0 10 5/16 ..	0 10 7/8 ..	0 11 3/8 ..	0 12 ..	1 0 9/16 ..	1 1⅛ ..	1 1 11/16 ..	1 2⅞ ..	1 4
1/8	6 9 ..	7 1½ ..	7 6 ..	7 10½ ..	8 3 ..	8 7½ ..	9 0 ..	9 9 ..	10 6
	0 10 1/8 ..	0 10 11/16 ..	0 11¼ ..	0 11 13/16 ..	1 0⅜ ..	1 0 15/16 ..	1 1½ ..	1 2⅝ ..	1 3¾
1/9	7 6 ..	7 11 ..	8 4 ..	8 9 ..	9 2 ..	9 7 ..	10 0 ..	10 10 ..	11 8
	0 10 ..	0 10 9/16 ..	0 11 1/8 ..	0 11 11/16 ..	1 0 5/16 ..	1 0¾ ..	1 1 5/16 ..	1 2 7/16 ..	1 3 9/16
1/10	8 3 ..	8 8½ ..	9 2 ..	9 7½ ..	10 1 ..	10 6½ ..	11 0 ..	11 11 ..	12 10
	0 9⅞ ..	0 10 7/16 .	0 11 ..	0 11 9/16 ..	1 0⅛ ..	1 0⅝ ..	1 1 3/16 ..	1 2 5/16 ..	1 3 7/16
1/12	9 9 ..	10 3½ ..	10 10 ..	11 4½ ..	11 11 ..	12 5½ ..	13 0 ..	14 1 ..	15 2
	0 9¾ ..	0 10 3/8 ..	0 10¾ ..	0 11⅜ ..	0 11⅞ ..	1 0½ ..	1 1 ..	1 2⅛ ..	1 3 1/16
1/14	11 3 ..	11 10½ ..	12 6 ..	13 1½ ..	13 9 ..	14 4½ ..	15 0 ..	16 3 ..	17 6
	0 9¾ ..	0 10⅜ ..	0 10¾ ..	0 11¼ ..	0 11¾ ..	0 12 5/16 ..	0 12⅞ ..	1 1 13/16 ..	1 3
1/16	12 9 ..	13 5⅛ ..	14 2 ..	14 10½ ..	15 7 ..	16 3½ ..	17 0 ..	18 5 ..	19 10
	0 9 9/16 ..	0 10 1/8 ..	0 10⅝ ..	0 11⅛ ..	0 11 11/16 ..	0 12¼ ..	0 12¾ ..	1 1 13/16 ..	1 2⅞
1/18	14 3 ..	15 0½ .	15 10 ..	16 7½ ..	17 5 ..	18 2½ ..	19 0 ..	20 7 ..	22 2
	0 9½ ..	0 10 ..	0 10 9/16 ..	0 11 1/16 ..	0 11⅝ ..	0 12¼ ..	0 12 11/16 ..	1 1 11/16 ..	1 2¾
1/20	15 9 ..	16 7½ ..	17 6 ..	18 4½ ..	19 3 ..	20 1½ ..	21 0 ..	22 9 ..	24 6
	0 9 7/16 ..	0 10 ..	0 10½ ..	0 11 ..	0 11 5/16 ..	0 12 1/16 ..	0 12⅜ ..	1 1⅝ ..	1 2 1/16
1/24	18 9 ..	19 9½ ..	20 10 ..	21 10½ ..	22 11 ..	23 11½ ..	25 0 ..	27 1 ..	29 2
	0 9 5/16 ..	0 9 15/16 ..	0 10 7/16 ..	0 10 15/16 .	0 11½ ..	0 12 ..	0 12½ ..	1 12 5/16 ..	1 2⅝
1/30	23 3 ..	24 6½ ..	25 10 ..	27 1½ ..	28 5 ..	29 8½ ..	31 0 ..	33 7 ..	36 2
	0 9 1/16 ..	0 9 13/16 ..	0 10 3/8 ..	0 10⅞ ..	0 11 3/8 ..	0 11 13/16 ..	1 0½ ..	1 1½ ..	1 2½
1/40	30 9 ..	32 5½ ..	34 2 ..	35 10½ ..	37 7 ..	39 3½ ..	41 0 ..	44 5 ..	47 10
	0 9¼ ..	0 9¾ ..	0 10¼ ..	0 10¾ ..	0 11¼ ..	0 11¾ ..	0 12 5/16 ..	1 1 5/16 ..	1 2 3/8
1/50	38 3 ..	40 4½ ..	42 6 ..	42 7½ ..	46 9 ..	48 10½ ..	51 0 ..	55 3 ..	59 6
	0 9 3/16 ..	0 9 11/16 ..	0 10 1/16 ..	0 10 11/16 ..	0 11 5/16 ..	0 11 15/16 ..	0 12¼ ..	1 1¼ ..	1 2¼
1/60	45 9 ..	48 3½ ..	50 10 ..	53 4½ ..	55 11 ..	58 5½ ..	61 0 ..	66 1 ..	71 2
	0 9 1/16 ..	0 9 11/16 .	0 10 5/16 ..	0 10 11/16 .	0 11 5/16 ..	0 11— ..	0 12¼ ..	1 1¼ ..	1 2¼
1/80	60 9 ..	64 1½ ..	67 6 ..	70 10½ ..	74 3 ..	77 7½ ..	81 0 ..	87 9 ..	94 6
	0 9⅛ ..	0 9 5/8 ..	0 10⅛ ..	0 10⅝ ..	0 11⅛ ..	0 11⅝ ..	0 12⅛ ..	1 1⅛ ..	1 2⅛
1/100	75 9 ..	79 11½ ..	84 2 ..	88 4½ ..	92 7 ..	96 9½ ..	101 0 ..	109 5 ..	117 10
	0 9 1/16 ..	0 9 15/16 ..	0 10 1/16 ..	0 10 5/16 ..	0 11⅛ ..	0 11 5/16 ..	0 12 1/16 ..	1 1⅛ ..	1 2⅛
1/120	90 9 ..	95 9½ ..	100 10 ..	105 10½ ..	110 11 ..	115 11½ ..	121 0 ..	131 1 ..	141 2
	0 9 1/16 ..	0 9 15/16 ..	0 10 1/16 ..	0 10 9/16 ..	0 11 1/16 ..	0 11 9/16 ..	0 12⅛ ..	1 1⅛ ..	1 2⅛
1/150	113 3 ..	119 6½ ..	125 10 ..	132 1½ ..	138 5 ..	144 8½ ..	151 0 ..	163 7 ..	176 2
	0 9 1/16 ..	0 9 15/16 ..	0 10 1/16 ..	0 10 1/16 ..	0 11 1/16 ..	0 11 9/16 ..	0 12 1/16 ..	0 13 1/16 ..	1 2 1/16
1/180	135 9 ..	143 3½ ..	150 10 ..	158 4½ ..	165 11 ..	173 5½ ..	181 0 ..	196 1 ..	211 2
	0 9 1/16 ..	0 9 15/16 ..	0 10 1/16 ..	0 10 1/16 ..	0 11 1/16 ..	0 11 9/16 ..	0 12 1/16 ..	0 1 1/16 ..	1 2 1/16
1/240	180 9 ..	190 9½ ..	200 10 ..	210 10½ ..	220 11 ..	230 11½ ..	241 0 ..	261 1 ..	281 2
	0 9 ..	0 9½ ..	0 10 ..	0 10½ ..	0 11 ..	0 11½ ..	0 12 ..	1 1 1/16 ..	1 2 1/16
1/300	225 9 ..	238 3½ ..	250 10 ..	263 4½ ..	275 11 ..	288 5½ ..	301 0 ..	326 1 ..	351 2
								1 1	1 2

TABLE IV.—FOR EQUIVALENT FOCI FROM 15IN. TO 23IN.

Relative Proportion of Image.	15	16	17	18	19	20	21	22	23
$\frac{1}{1}$	2 6 ..	2 8 ..	2 10 ..	3 0 ..	3 2 ..	3 4 ..	3 6 ..	3 8 ..	3 10 ..
	2 6 ..	2 8 ..	2 10 ..	3 0 ..	3 2 ..	3 4 ..	3 6 ..	3 8 ..	3 10 ..
$\frac{1}{2}$	3 9 ..	4 0 ..	4 3 ..	4 6 ..	4 9 ..	5 0 ..	5 3 ..	5 6 ..	5 9
	1 10½..	2 0 ..	2 1½..	2 3 ..	2 4½..	2 6 ..	2 7½..	2 9 ..	2 10⅛
$\frac{1}{3}$	5 0 ..	5 4 ..	5 8 ..	6 0 ..	6 4 ..	6 8 ..	7 0 ..	7 4 ..	7 8
	1 8 ..	1 9⅝..	1 10⅛..	2 0 ..	2 1⅝..	2 2⅛..	2 4 ..	2 5⅝..	2 6⅛
$\frac{1}{4}$	6 3 ..	6 8 ..	7 1 ..	7 6 ..	7 11 ..	8 4 ..	8 9 ..	9 2 ..	9 7
	1 6¾..	1 8 ..	1 9¼..	1 10½..	1 11¾..	2 1 ..	2 2¼..	2 3¼..	2 4¾
$\frac{1}{5}$	7 6 ..	8 0 ..	8 6 ..	9 0 ..	9 6 ..	10 0 ..	10 6 ..	11 0 ..	11 6
	1 6 ..	1 7⅛..	1 8⅜..	1 9⅝..	1 10⅛..	2 0 ..	2 1⅛..	2 2⅜..	2 3⅝
$\frac{1}{6}$	8 9 ..	9 4 ..	9 11 ..	10 6 ..	11 1 ..	11 8 ..	12 3 ..	12 16 ..	13 5
	1 5½..	1 6⅛..	1 7⅞..	1 9 ..	1 10⅛..	1 11⅝..	2 0½..	2 1⅛..	2 2⅛
$\frac{1}{7}$	10 0 ..	10 8 ..	11 4 ..	12 0 ..	12 8 ..	13 4 ..	14 0 ..	14 8 ..	15 4
	1 5⅛..	1 6⅝..	1 7⅜..	1 8⅝..	1 9⅛..	11 0⅞..	2 0 ..	2 1⅛..	2 2¼
$\frac{1}{8}$	11 3 ..	12 0 ..	12 9 ..	13 6 ..	14 3 ..	15 0 ..	15 9 ..	16 6 .	17 3
	1 4⅞..	1 6 ..	1 7⅛..	1 8¼..	1 9⅜..	1 10½..	1 11⅝..	2 0¾..	2 1⅞
$\frac{1}{9}$	12 6 ..	13 4 ..	14 2 ..	15 0 ..	15 10 ..	16 8 ..	17 6 ..	18 4 ..	19 2
	1 4⅛..	1 5⅛..	1 6⅛..	1 8 ..	1 9⅛..	1 10¼..	1 11⅝..	2 0⅞ .	2 1⅝
$\frac{1}{10}$	13 9 ..	14 8 ..	15 7 ..	16 6 ..	17 5 ..	18 4 ..	19 3 ..	20 2 ..	21 1
	1 4½.	1 5⅜..	1 6¾..	1 7⅞..	1 9 ..	1 10 ..	1 11⅛..	2 0⅜..	2 1¼
$\frac{1}{12}$	16 3 ..	17 4 ..	18 5 ..	19 6 ..	20 7 ..	21 8 ..	22 9 ..	23 10 ..	24 11
	1 4¼..	1 5⅛..	1 6⅜.	1 7½..	1 8⅝..	1 9⅝..	1 10¾..	1 11⅞..	2 0⅛
$\frac{1}{14}$	18 9 ..	20 0 ..	21 3 ..	22 6 ..	23 9 .	25 0 ..	26 3 ..	27 6 ..	28 9
	1 4⅛..	1 5⅛..	1 6¼..	1 7⅝..	1 8⅜..	1 9⅞..	1 10½..	1 11⅝..	2 0⅝
$\frac{1}{16}$	21 3 ..	22 8 ..	24 1 ..	25 6 ..	26 11 ..	28 4 ..	29 9 ..	31 2 ..	32 7
	1 3⅛..	1 5 ..	1 6⅛..	1 7⅛..	1 8¼..	1 9¼..	1 10⅝..	1 11⅜..	2 0⅞
$\frac{1}{18}$	23 9 ..	25 4 ..	26 11 ..	28 6 ..	30 1 ..	31 8 ..	33 3 ..	34 10 ..	36 5
	1 3⅛..	1 4⅞..	1 5⅛..	1 7 ..	1 0⅛..	1 9⅛..	1 10⅜..	1 11¼..	2 0⅛
$\frac{1}{20}$	26 3 ..	28 0 ..	29 9 ..	31 6 ..	33 3 ..	35 0 ..	36 9 ..	38 6 ..	40 3
	1 3¾..	1 4⅛..	1 5⅞..	1 6⅛..	1 8 ..	1 9 ..	1 10⅛..	1 11⅛..	2 0⅛
$\frac{1}{24}$	31 3 ..	33 4 ..	35 5 ..	37 6 ..	39 7 ..	41 8 ..	43 9 ..	45 10 ..	47 11
	1 3⅝..	1 4⅛..	1 5¾..	1 6¾..	1 7⅛..	1 8⅛..	1 9⅞..	7 10⅛..	2 0
$\frac{1}{30}$	38 9 ..	41 4 ..	43 11 ..	46 6 ..	49 1 ..	51 8 ..	54 3 ..	56 10 ..	59 5
	1 3½..	1 4⅛ .	1 5⅛..	1 6⅜..	8 7⅝..	1 8⅝..	1 9⅛..	1 10¾..	1 11¾
$\frac{1}{40}$	51 3 ..	54 8 ..	58 1 ..	61 6 ..	64 11 ..	68 4 ..	71 9 ..	75 2 ..	78 7
	1 3⅜..	1 4⅞..	1 5⅞..	1 6⅞..	1 7⅛..	1 8½..	1 9½..	1 10½..	1 11⅝
$\frac{1}{50}$	63 9 ..	68 0 ..	72 3 ..	76 6 ..	80 9 ..	85 0 ..	89 3 ..	93 6 ..	97 9
	1 3⅛..	1 4⅜..	1 5⅛..	1 6⅜..	1 7⅜..	1 8⅜..	1 9⅜..	1 10⅞..	1 11½
$\frac{1}{60}$	76 3 ..	81 4 ..	86 5 ..	91 6 ..	96 7 ..	101 8 ..	106 9 ..	111 10 ..	116 11
	1 3¼..	1 4⅜..	1 5⅛..	1 6⅝..	1 7⅛..	1 8⅛..	1 9⅝..	1 10⅜..	1 11⅜
$\frac{1}{80}$	101 3 ..	108 0 ..	114 9 ..	121 6 ..	128 3 ..	135 0 ..	141 9 ..	148 6 ..	155 3
	1 3⅛..	1 4⅜..	1 5⅜..	1 6¼..	1 7¼..	1 8¼..	1 9¼..	1 10¼..	1 11⅛
$\frac{1}{100}$	126 3 ..	134 8 ..	143 1 ..	151 6 ..	159 11 ..	168 4 ..	176 9 ..	185 2 ..	193 7
	1 3⅛..	1 4⅛..	1 5⅛..	1 6⅜ .	1 7⅛..	1 8⅜..	1 9⅜..	1 10⅛..	1 11¼
$\frac{1}{120}$	151 3 ..	161 4 ..	171 5 ..	181 6 ..	191 7 ..	201 8 ..	211 9 ..	221 10 ..	231 11
	1 3⅛..	1 4⅛..	1 5⅛..	1 6⅛..	1 7⅜..	1 8⅜..	1 9⅜..	1 10⅜..	1 11⅜
$\frac{1}{150}$	188 9 ..	201 4 ..	213 11 ..	226 6 ..	239 1 ..	251 8 ..	264 3 ..	276 10 ..	289 5
	1 3⅛..	1 4⅛..	1 5⅛..	1 6⅛..	1 7⅛..	1 8⅛..	1 9⅛..	1 10⅛..	1 11⅛
$\frac{1}{180}$	226 3 ..	241 4 ..	256 5 ..	271 6 ..	286 7 ..	301 8 ..	316 9 ..	331 10 ..	346 11
	1 3⅛..	1 4⅛..	1 5⅛..	1 6⅛..	1 7⅛..	1 8⅛..	1 9⅛..	1 10⅛..	1 11⅛
$\frac{1}{240}$	301 3 ..	321 4 ..	347 5 ..	361 6 ..	381 7 ..	401 8 ..	421 9 ..	441 10 ..	461 11
	1 3⅛..	1 4⅛..	1 5⅛..	1 6⅛..	1 7⅓..	1 8⅛..	1 9⅛..	1 10⅛..	1 11⅛
$\frac{1}{300}$	376 3 ..	401 4 ..	426 5 ..	451 6 ..	476 7 ..	501 8 ..	526 9 ..	551 10 ..	576 11
	1 3 ..	1 4⅛..	1 5⅛..	1 6⅛..	1 7⅛..	1 8⅛..	1 9⅛..	1 10⅛..	1 11⅛

FOR EQUIVALENT FOCI FROM 24IN. TO 36IN.

Relative Proportion of Image.	24	25	26	27	28	29	30	32	36
1/1	4 0 ..	4 2 ..	4 4 ..	4 6 .	4 8 ..	4 10 ..	5 0 ..	5 4 ..	6 0
	4 0 ..	4 2 ..	4 4 ..	4 6 ..	4 8 ..	4 10 ..	5 0 ..	5 4 ..	6 0
1/2	6 0 ..	6 3 ..	6 6 ..	6 9 ..	7 0 ..	7 3 ..	7 6 ..	8 0 ..	9 0
	3 0 ..	3 1½..	3 3 ..	3 4½..	3 6 ..	3 7½..	3 9 ..	4 0 ..	4 6
1/3	8 0 ..	8 4 ..	8 8 ..	9 0 ..	9 4 ..	9 8 ..	10 0 ..	10 8 ..	12 0
	2 8 ..	2 9 5/16..	2 10 11/16..	3 0 ..	3 1 5/16..	3 2 11/16..	3 4 ..	3 6 11/16..	4 0
1/4	10 0 ..	10 5 ..	10 10 ..	11 3 ..	11 8 ..	12 1 ..	12 6 ..	13 4 ..	15 0
	2 6 ..	2 7¼..	2 8½..	2 9¾..	2 11 ..	3 0¼..	3 1½..	3 4 ..	3 9
1/5	12 0 ..	12 6 ..	13 0 ..	13 6 ..	14 0 ..	14 6 ..	15 0 ..	16 0 ..	18 0
	2 4 1/16..	2 6 ..	2 7 3/16..	2 8⅜..	2 9⅝..	2 10 1/16..	3 0 ..	3 2⅜..	3 7 8/16
1/6	14 0 .	14 7 ..	15 2 ..	15 9 ..	16 4 ..	16 11 ..	17 6 ..	18 8 ..	21 0
	2 4 ..	2 5 8/16..	2 6 5/16..	2 7½..	2 8 11/16..	2 9 7/8..	2 11 ..	3 0¾..	3 6
1/7	16 0 ..	16 8 ..	17 4 ..	18 0 ..	18 8 ..	19 4 ..	20 0 ..	21 4 ..	24 0
	2 3 7/16..	2 4 3/16..	2 5 1/16..	2 6⅞..	2 8 ..	2 9⅛..	2 10 5/16..	3 0 9/16..	3 5⅛
1/8	18 0 ..	18 9 ..	19 6 ..	20 3 ..	21 0 ..	21 9 ..	22 6 ..	24 0 ..	27 0
	2 3 ..	2 4⅛..	2 5¼..	2 6⅜..	2 7½..	2 8⅝..	2 9¾..	3 0 ..	3 4½
1/9	20 0 ..	20 10 ..	21 8 ..	22 6 ..	23 4 ..	24 2 ..	25 0 ..	26 8 ..	30 0
	2 2 11/16..	2 3¾..	2 4⅞..	2 6 ..	2 7⅛..	2 8¼..	2 9⅜..	2 11 9/16..	3 4
1/10	22 0 ..	22 11 ..	23 10 ..	24 9 ..	25 8 ..	26 7 ..	27 6 ..	29 4 ..	33 0
	2 2⅜..	2 3½..	2 4⅝..	2 5 11/16..	2 6 13/16..	2 7⅞..	2 9 ..	2 11¼..	3 3⅜
1/12	26 0 ..	27 1 ..	28 2 ..	29 3 ..	30 4 ..	31 5 ..	32 6 ..	34 8 ..	39 0
	2 2 ..	2 3 1/16..	2 4⅛..	2 5¼..	2 6 5/16..	2 7 7/16..	2 8½..	2 10⅝..	3 3
1/14	30 0 ..	31 3 ..	32 6 ..	33 9 ..	35 0 ..	36 3 ..	37 6 ..	40 0 ..	45 0
	2 1 11/16..	2 2¾..	2 3⅞..	2 4 15/16..	2 6 ..	2 7 1/16..	2 8⅛..	2 10¼..	3 2⅝
1/16	34 0 ..	35 5 ..	36 10 ..	38 3 ..	39 8 ..	41 1 ..	42 6 ..	45 4 ..	51 0
	2 1½..	2 2 9/16..	2 3 10/16..	2 4 11/16..	2 5¾..	2 6 13/16..	2 7⅞..	2 10 ..	3 6¾
1/18	38 0 ..	39 7 ..	41 2 ..	42 9 ..	44 4 ..	45 11 ..	47 6 ..	50 8 ..	57 0
	2 1⅜..	2 2 7/16..	2 3½..	2 4 9/16..	2 5⅝..	2 6 11/16..	2 7¾..	2 9⅞..	3 2
1/20	42 0 ..	43 9 ..	45 6 ..	47 3 ..	49 0 ..	50 9 ..	52 6 ..	56 0 ..	63 0
	2 1 1/16..	2 2¼..	2 3 5/16..	2 4⅜..	2 5 7/16..	2 6½..	2 7 9/16..	2 9⅝..	3 1 3/16
1/24	50 0 ..	52 1 ..	54 2 ..	56 3 ..	58 4 ..	60 5 ..	62 6 ..	66 8 ..	75 0
	2 1 ..	2 2 ..	2 3 1/16..	2 4⅛..	2 5⅛..	2 6 3/16..	2 7¼..	2 9⅜..	3 1½
1/30	62 0 ..	64 7 ..	67 2 ..	69 9 ..	72 4 ..	74 11 ..	77 6 ..	82 8 ..	93 0
	2 0 13/16..	2 1⅞..	2 2⅞..	2 3 15/16..	2 4 15/16..	2 6 ..	2 7 ..	2 9 1/16..	3 1 3/16
1/40	82 0 ..	85 5 ..	88 10 ..	92 3 ..	95 8 ..	99 1 ..	102 6 ..	109 4 ..	123 0
	2 0 9/16..	2 1⅝..	2 2⅝..	2 3 11/16..	2 4 11/16..	2 5¾..	2 6¾..	2 8 13/16..	3 0⅜
1/50	102 0 ..	106 3 ..	110 6 ..	114 9 ..	119 0 ..	123 3 ..	127 6 ..	136 0 ..	153 0
	2 0½..	2 1½..	2 2½..	2 3½..	2 4 9/16..	2 5⅝..	2 6⅝..	2 8⅝..	3 0⅝
1/60	122 0 ..	127 1 ..	132 2 ..	137 3 ..	142 4 ..	147 5 ..	152 6 ..	162 8 ..	183 0
	2 0⅜..	2 1 7/16..	2 2½..	2 3½..	2 4½..	2 5½..	2 6½..	2 8½..	3 0½
1/80	162 0 ..	168 9 .	175 6 ..	182 3 ..	189 0 ..	195 9 ..	202 6 ..	216 0 ..	243 0
	2 0 5/16..	2 1 5/16..	2 2 5/16..	2 3 5/16..	2 4⅜..	2 5⅜..	2 6⅜..	2 8⅜..	3 0 7/16
1/100	202 0 ..	210 5 ..	218 10 ..	227 3 ..	235 8 ..	244 1 ..	252 6 ..	269 4 ..	303 0
	2 0¼..	2 1¼..	2 2¼..	2 3¼..	2 4¼..	2 5¼..	2 6¼..	2 8 5/16..	3 0⅜
1/120	242 0 ..	252 1 ..	262 2 ..	272 3 ..	282 4 ..	292 5 ..	302 6 ..	322 8 ..	363 0
	2 0 3/16..	2 1 3/16..	2 2 3/16..	2 3 3/16..	2 4¼..	2 5¼..	2 6¼..	2 8¼..	3 0 5/16
1/150	302 0 ..	314 7 ..	327 2 ..	339 9 ..	352 4 ..	364 11 ..	377 6 ..	402 8 ..	453 0
	2 0⅛..	2 1⅛..	2 2⅛..	2 3⅛..	2 4 3/16..	2 5 3/16..	2 6 3/16..	2 8 3/16..	3 0¼
1/180	362 0 ..	377 1 ..	392 2 ..	407 3 ..	422 4 ..	437 5 ..	452 6 ..	482 8 ..	543 9
	2 0⅛..	2 1⅛..	2 2⅛..	2 3⅛..	2 4⅛..	2 5⅛..	2 5⅛..	2 8 3/16..	3 0 3/16
1/240	482 0 ..	502 1 ..	522 2 ..	542 3 ..	562 4 ..	582 5 ..	602 6 ..	642 8 ..	723 0
	2 0 1/16..	2 1 1/16..	2 2 1/16..	2 3 1/16..	4 4 1/16..	2 5 1/16..	2 6⅛..	2 8⅛..	3 0⅛
1/300	602 0 ..	627 1 ..	652 2 ..	677 3 ..	702 4 ..	727 5 ..	752 6 ..	802 8 ..	903 0
	2 0 1/16..	2 1 1/16..	2 2 1/16..	2 3 1/16..	2 4 1/16..	2 5 1/16..	2 6⅛..	2 8⅛..	3 0⅛

Proportion to Natural Size.	Size of Image.		Proportion to Natural Size.	Size of Image.	
	Of a Man.	Of a Head.		Of a Man.	Of a Head.
	Ft. In.	Ft. In.		Ft. In.	Ft In.
1/1	5 9	0 9	1/20	0 3 7/16	0 0 7/16
1/2	2 10 1/2	0 4 1/2	1/24	0 2 7/8	0 0 3/8
1/3	1 11	0 3	1/30	0 2 5/16	0 0 5/16
1/4	1 5 1/4	0 2 1/4	1/40	0 1 3/4	0 0 1/4 Approx.
1/5	1 1 13/16	0 1 3/4	1/50	0 1 3/8	0 0 3/61 "
1/6	0 11 1/2	0 1 1/2	1/60	0 1 1/8	..
1/7	0 9 13/16	0 1 5/16	1/80	0 0 7/8	0 0 1/8 "
1/8	0 8 9/16	0 1 1/8	1/100	0 0 11/16	..
1/9	0 7 5/8	0 1	1/120	0 0 5/8	..
1/10	0 6 7/8	0 0 7/8	1/150	0 0 7/16	0 0 5/16
1/12	0 5 3/4	0 0 3/4	1/180	0 0 3/8	..
1/14	0 4 15/16	0 0 5/8	1/240	0 0 5/16 Approx.	..
1/16	0 4 5/16	0 0 9/16	1/300	0 0 1/4	..
1/18	0 3 7/8	0 0 1/2			

CONTACT, OPTICAL.—See **Optical Contact.**

CONTACT PAPERS.—Sensitized papers used for contact printing.

CONTACT PRINTING.—Used to describe those processes in which the paper or glass is printed in contact with the negative. The term is more often applied, however, to printing upon bromide paper placed behind and in contact with the negative held a few feet from a light. Thin negatives give the best prints if a weak yellow light be used. The light from an ordinary oil lamp answers well if turned down below its usual intensity. Strong negatives should be printed in daylight.

CONTINUING ACTION OF LIGHT.—For some time it was believed that if exposed plates were kept for any length of time previous to development a continuing action of light took place, with the result that correctly exposed plates would become over-exposed, and under-exposed plates would reach the requisite amount of ripeness if kept for a sufficient length of time. It has been proved, however, that no measurably appreciable alteration takes place in the undeveloped silver image between the time of exposure and development, and that an under-exposed picture will be just as under-exposed if kept for many months previous to developing.

In the autotype or carbon process, however, a continuing action does actually take place; due to the action of the light in the first place, and afterwards to the presence of moisture in the atmosphere. See **Carbon Process.**

CONTRAST.—A negative is said to possess great contrast when the high-lights and shadows show much dissimilitude.

CONTRETYPE.—This term has been given by Prof. Corsi to his process of obtaining positives direct in the camera. The plate is exposed in the camera and developed as usual, care being exercised, however, that it is not fogged. It should be then well washed till quite free from the developer. The following solutions are required:

A.

Saturated solution of chrome alum.

B.

Boric acid	1.5 parts
Water	500 parts

C.

Solution A	20 parts
Solution B	10 parts
Water	1000 parts

D.

Potassium bichromate	25 parts
Nitric acid	10 parts
Solution A	25 parts
Water	1000 parts

E.

Potassium hydrate	2 parts
Potassium bromide	2 parts
Water	1000 parts

Place the developed and well-washed negative in solution D till the black image is quite converted into a red one; then wash well in three successive baths of solution C and soak in solution E till the red image disappears, and thoroughly wash. Expose the plate to diffused light for about 30 seconds, or to lamp or gaslight for about five to ten minutes, and then develope with a well-restrained eikonogen or paramidophenol developer.

CONVERGENT.—A term used in optics to rays of light which being continued will meet in a focus.

CONVERGENT LENS.—A lens that will cause rays of light to converge and meet in a focus.

CONVEX.—In optics a lens or mirror having the surface of a sphere.

CONVEXO-CONCAVE.—Convex on the one side and concave on the other. A lens having this form is also termed a meniscus.

CONVEXO-CONVEX.—Convex on both sides. Synonym, double convex.

CONVEXO-PLANE.—Convex on one side and plane on the other. Synonym, plano-convex.

COOKING.—In the gelatine dry plate process the emulsion undergoes a process of cooking, to give increased sensitiveness. See **Emulsion.**

COOLING CHAMBER.—An arrangement used in the manufacture of dry plates, *q. v.* It is used in warm weather for cooling the gelatine emulsion.

COOPER'S PROCESS.—A printing process, the invention of Mr. Henry Cooper The basis of the process lies in the substitution of a resin or substance of a resinous nature, in the place of albumen or other sizing matter. Prints obtained by this process have a more artistic appearance than pictures printed upon albumenised paper, and they are devoid of inartistic gloss. The two formulas given were communicated to Captain Abney by the inventor.*

Frankincense	10 grains
Mastic	8 grains
Calcium chloride	5 to 10 grains
Alcohol	1 ounce

As soon as the resins are completely dissolved in the alcohol, the paper to be prepared is immersed in the solution, and then taken out, dried and rolled. It is best to hang the paper in drying, and to increase the temperature of the room to about 80 deg. Fahr.

The sensitizing silver bath recommended is made up as follows:

Silver nitrate	60 grains
Water	1 ounce

To the water as much gelatine should be added as possible without gelatinizing at 60 deg. Fahr.

The second formula alluded to gives very fine prints, remarkable for their softness and delicacy of gradation of the half tones.

A suitable paper is first prepared by coating with an emulsion of white lac in gelatine. This is prepared by dissolving three ounces of fresh white lac in a pint of strong alcohol It is important that the lac be fresh, as on exposure to the air it becomes insoluble after a time. When dissolved it is filtered and decanted, and as much water added as it will possibly bear without precipitating the lac. To find out the largest quantity of water permissible, take a given quantity of the solution in a test tube and add water minim by minim until the lac is precipitated. A careful calculation will then show how much water to add to the bulk of the solution, which will, of course, be under the amount required for precipitation.

One ounce of good hard gelatine is next soaked in a pint of cold water, and when soaked the temperature is raised to between 180 to 200 deg. Fahr., when the lac solution is added, constantly agitating the solution the while. It sometimes happens that at this stage the gelatine becomes precipitated. A little hot water should at once be added. The pint of lac solution should, however, be emulsified in the gelatine solution.

To prepare the paper, the emulsion is just warmed and placed on a flat dish, and the paper either immersed in or floated on the solution for about three minutes. It is then hung up to dry. When dry, the coated surface is floated for about two minutes on

Ammonium chloride	10 grains
Magnesium or ammonium lactate	10 grains

It is again put away to dry, when it is ready for sensitizing, which should be done on a moderately strong bath. This will answer well:

* Abney's "Instructions in Photography," eighth edition.

Silver nitrate	50 grains
Distilled water	1 ouuce

To obtain a great amount of vigor in the prints, they may be floated on

Citric acid	5 grains
White sugar	5 grains

This bath will be found to improve by use, due in all probability to its absorbing silver nitrate from the paper after sensitizing.

Cooper's toning formula is the following:

Gold trichloride	2 grains
Precipitate chalk (pure)	a pinch
Hot water	10 ounces

Two drachms of sodium acetate are placed in the stock bottle, and this solution filtered on to it. Water is then added to make up to 20 ounces, and in a few hours the solution is ready for use. It improves by keeping, however.

In toning, place a few ounces of water in the dish, and add an equal quantity of the stock solution. The prints are then laid in, and if the toning process is slow, some more of the solution is added. Over-toning is to be avoided in this process. Fixing is done with sodium hyposulphite in the usual manner.

COPAL.—A resinous substance produced by the plant *Rhus copallinium*, which grows in Mexico, and from the *Elæocarpus copalifer*, which grows in India. It is also obtained from Africa and the coast of Guinea. It is obtained in round semi-transparent masses, colorless, and slightly yellow and very brittle. It is soluble in alcohol, ether, and essential oils. It is largely used in the making of varnishes, *q. v.*

COPPER (Symbol, Cu).—The metal copper is too well-known to require description. It is employed in photography to precipitate the silver from old fixing baths.

COPPER ACETATE [Formula, $Cu(C_3H_3O_2)_2, H_2O$; molecular weight, 199].—Prepared by the solution of copper oxide or hydrate in acetic acid or by the action of copper sulphate on acetate of lead or barium. It forms prismatic crystals of a deep green color, soluble in water and alcohol. There exists a mixture of basic acetates of copper called veildepis.

COPPERAS.—See **Ferrous Sulphate.**

COPPER BROMIDE.—See **Cupric Bromide.**

COPPER CHLORIDE.—See **Cupric Chloride.**

COPPER OXIDES.—Two oxides of copper are at present known, the red or sub-oxide (cuprous oxide), Cu_2O, and the black or protoxide (cupric oxide), CuO. Both are valuable ones, and occur native. The cuprous oxide may be prepared artificially by the addition of grape sugar to a solution of blue sulphate of copper, treating the product with an excess of caustic potash, and then boiling the solution. The sub-oxide gives a fine ruby red color to glass, and can be used for making non-actinic media for dark-room windows. Protoxide of copper can be prepared artificially by calcining copper, or by the ignition of copper sulphate or nitrate. It communicates a green color to glass, which can be used for rooms in which the sensitizing of photographic paper or other similar operations take place. It is sufficiently non-actinic, and possesses the advantage of being far more agreeable and less hurtful to the eyes than a red or yellow color.

COPPER PROCESS.—An unused process, introduced by Obernetter. It is based upon the fact that copper forms with chlorine a green salt, soluble in water—chloride of copper. This is sensitive to light, which reduces it to hypo-chloride of copper. Paper is saturated with a mixture of copper chloride and iron chloride. This when dry is exposed to the light under a negative, and afterwards plunged into a solution of potassium sulphocyanide, and ultimately treated with red prussiate of potash. The result is a brown picture.

COPPER SULPHATE (Formula $CuSO_4+5H_2O$. Molecular weight, 249.2. Synonyms, *Cupric Sulphate*, *Blue Vitriol*).—A salt prepared by dissolving copper oxide in sulphuric acid.* It can also be prepared from the metal itself. Copper plates are heated to dull redness and plunged into dilute sulphuric acid. Copper sulphate forms large blue transparent crystals, soluble in water. It is sometimes added to the ferrous sulphate developer in the wet collodion process.

COPPER SULPHIDES.—There are two distinct sulphides of copper which may be prepared. Copper and sulphide, when melted together, combine with vivid incandescence, and produce the subsulphide (cuprous sulphide), Cu_2S. Cupric sulphide is found native as covellite, but can be artificially prepared by precipitating a salt of copper with sulphuretted hydrogen.

* It is prepared on a large scale by the oxidization of copper pyrites (sulphide of copper.)

COPYING.—This term is usually applied to the copying of engravings, drawings, plans sketches, etc., with the camera. A suitable camera for this purpose is depicted in Fig. 140. The lens which should be employed in copying should be a landscape doublet or triplet, or a portrait combination. Single lenses cannot be used without distorting the lines of the copy. It is advisable to use one possessing the least possible distortion. Abney recommends a Dallmeyer's D lens with a small stop. In photographing it is necessary that the copy and the screen of the camera be both perfectly upright, and in consequence parallel to each other. A good form of copying stand is shown in Fig. 141. The light should fall direct upon the copy in a horizontal direction. If side lights be used the texture of the paper is clearly represented, giving the picture an unnatural, rough appearance. The light should also be a brilliant one; for Indian ink or sepia sketches direct sunlight should be used. If it should be required to enlarge or reduce the image, information will be found under **Enlarging**.

FIG. 140.—COPYING CAMERA.

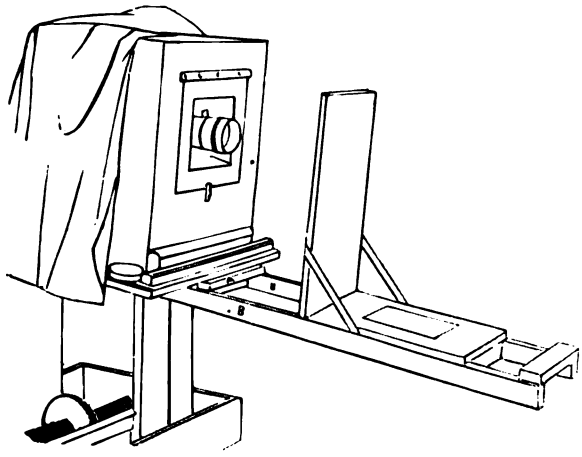


FIG. 141.

When copying it is very advisable that there should be as little vibration or movement as possible. To avoid this the camera and board to hold the copy is suspended as shown in Fig. 141. By this arrangement, if any part be accidentally touched during exposure, it is of no consequence as the whole moves together.

For copying pictures in black and white ordinary dry plates will answer the purpose, but are inferior to collodion wet plates, which are almost universally used for this purpose. They give better brilliancy and contrast, and the increased exposure is in this case of no consequence. A plain iodized collodion should be used, and the plates developed with the ferrous sulphate or the pyrogallic developer described in the collodion wet process.

COPYING PAINTINGS.—For copying paintings, or any description of colored picture, it will be sometimes necessary to employ orthochromatic or isochromatic plates, which materially assist in rendering the colors in their true relation to each other. With ordinary plates the yellows have hardly any action at all, while the blues have a very bright action. This process is fully described under **Isochromatic Photography**, and is equally serviceable in photographing manuscripts or engaavings which have become yellow by age. It gives increased sensitiveness to this yellow, which would otherwise have but little effect upon the plate.

COPYING PHOTOGRAPHS.—Photographs may be copied in the same manner as described above, using a strong light.

COPYRIGHT LAW OF THE UNITED STATES.—1. A *printed* copy of the title of the book, map, chart, dramatic or musical composition, engraving, cut, print, photograph, or chromo, or a *description* of the painting, drawing, statue, statuary, or model or design for a work of the fine arts, for which copyright is desired, must be delivered to the Librarian of Congress or deposited in the mail, within the United States, *prepaid*, addressed

LIBRARIAN OF CONGRESS, Washington, D. C.

This must be done on or before day of publication in this or any foreign country.

The *printed title* required may be a copy of the title page of such publications as have title pages. *In other cases the title must be printed expressly for copyright entry*, with name of claimant of copyright. The style of type is immaterial, and the print of a typewriter will be accepted. But a separate title is required for each entry, and *each* title must be printed on paper as large as commercial note. The title of a *periodical* must include the date and number; and each number of the periodical requires a separate entry of copyright.

2. The legal fee for *recording* each copyright claim is 50 cents, and for a *copy* of this record (or certificate of copyright under seal of the office) an additional fee of 50 cents is required,

making $1, if certificate is wanted, which will be mailed as soon as reached in the records. Publications which are the production of persons not citizens or residents of the United States, the fee for recording title is $1, and 50 cents additional for a copy of the record. Certificates covering more than one entry in one certificate are not issued.

3. Not later than the day of publication in this country or abroad, two complete copies of the best edition of each book or other article must be delivered, or deposited in the mail within the United States, addressed

LIBRARIAN OF CONGRESS, Washington, D. C.,

to perfect the copyright.

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Without the deposit of copies above required the copyright is void, and a penalty of $25 is incurred. No copy is required to be deposited elsewhere.

The law requires one copy of each new edition, wherein any substantial changes are made, to be deposited with the Librarian of Congress.

4. No copyright is valid unless notice is given by inserting in every copy published, on the title page or the page following, if it be a book; or if a map, chart, musical composition, print, cut, engraving, photograph, painting, drawing, chromo, statue, statuary, or model or design intended to be perfected as a work of the fine arts, by inscribing upon some portion thereof, or on the substance on which the same is mounted, the following words, viz.: "*Entered according to act of Congress in the year* ———, *by* ———, *in the office of the Librarian of Congress, at Washington,*" or at the option of the person entering the copyright, the words: "'"*Copyright 18*—, *by* ———."

The law imposes a penalty of $100 upon any person who has not obtained copyright who shall insert the notice "*Entered according to act of Congress,*" or "*Copyright,*" etc., or words of the same import, in or upon any book or other article.

5. The copyright law secures to authors and their assigns the exclusive right to translate or to dramatize any of their works; no notice or record is required to enforce this right.

6. The original term of copyright runs for twenty-eight years. *Within six months before* the end of that time, the author or designer, or his widow or children, may secure a renewal for the further term of fourteen years, making forty-two years in all. Applications for renewal must be accompanied by a printed title and fee; and by explicit statement of ownership, in the case of the author, or of relationship, in the case of his heirs, and must state definitely the date and place of entry of the original copyright. Within two months of date of renewal the record thereof must be advertised in an American newspaper four weeks.

7. The time of publication is not limited by any law or regulation, but the courts have held that it should take place within a reasonable time. A copyright may be secured for a projected as well as for a complete work. But the law provides for no *caveat*, or notice of interference—only for actual entry of title.

8. Copyrights are assignable by any instrument of writing. Such assignment, to be valid, is to be recorded in the office of the Librarian of Congress within sixty days from execution. The fee for this record and certificate is one dollar, and for a certified copy of any record of assignment, one dollar.

9. A copy of the record (or duplicate certificate) of any copyright entry will be furnished under seal of the office, at the rate of fifty cents each.

10. In the case of books published in more than one volume, or of periodicals published in numbers, or of engravings, photographs, or other articles published with variations, a copyright must be entered for each volume or part of a book, or number of a periodical, or variety, as to style, title, inscription, of any other article. To *complete* the copyright on a book published serially in a periodical, two copies of each serial part as well as of the complete work (if published separately), should be deposited.

11. To secure copyright for a painting, statue, model or design intended to be perfected as a work of the fine arts, a definite title and description must accompany the application for copyright, and a mounted photograph of the same, as large as "cabinet size," mailed to the Librarian of Congress not later than the day of publication of the work or design.

The fine arts, for copyright purposes, include only painting and sculpture, and articles of merely ornamental and decorative art should be sent to the Patent Office, as subjects for Design Patents.

12. Copyrights cannot be granted upon Trade-Marks, nor upon names of companies, libraries, or articles, nor upon an idea or device, nor upon prints or labels intended to be used for any article of manufacture. If protection for such names or labels is desired, application must be made to the Patent Office, where they are registered, if admitted, at a fee of $6 for labels, and $25 for trade-marks.

13. The provisions as to copyright entry in the United States by foreign authors, etc., by act of Congress approved March 3, 1891 (which took effect July 1, 1891), are the same as the foregoing, except as to productions of persons, not citizens or residents, which must cover return postages, and are $1 for entry, or $1.50 for entry and certificate of entry (equivalent to 4*s.* 5*d.* or 6*s* 7*d.*). All publications must be delivered to the Librarian at Washington free of charge. The free penalty labels cannot be used outside of the United States.

The right of citizens or subjects of a foreign nation to copyright in the United States extends by Presidential proclamations of July 1, 1891, April 15, and October 31, 1892, to Great Britain, France, Belgium, Switzerland, Germany, and Italy.

14. Every applicant for a copyright should state distinctly the full name and residence of the claimant, and whether the right is claimed as author, designer, or proprietor. No affidavit or witness to the application is required.

CORK.—The bark of the *Quercus Suber*, or cork oak, a tree which grows in France, Italy, Spain, and several other countries. It is a very elastic tissue, and is largely used for making corks for stopping the mouths of bottles, jars, etc. The bark is stripped from the tree in square sections, steeped in water, flattened with weights, and dried before fires. For the protection of chemicals good corks should be used. Those known as velvet corks are the finest quality, and are imported in large quantities from France. Corks should not be placed in bottles containing acids or any substances of a like nature. For these purposes glass stoppered bottles should be used.

To make corks perfectly air-tight they are soaked in melted paraffin-wax.

CORK EXTRACTOR.—An instrument for removing corks from bottles. Fig. 142 will explain its use.

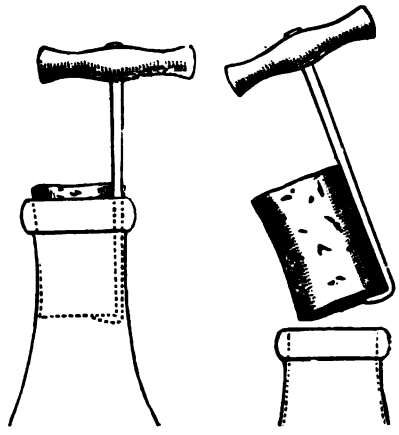


FIG. 142.—CORK EXTRACTOR.

CORK, PRINTING ON.—Prints may be made upon thin sheets of cork, if treated in the same manner as described in the process of printing on wood (*q.v.*).

CORN STARCH PASTE.—See **Mountants.**

CORRECTOR.—See **Photo-Corrector.**

CORROSIVE SUBLIMATE.—See **Mercuric Chloride.**

CORUNDUM FILE.—A piece of corundum formed into a convenient shape for taking the sharp edges from a glass plate and rounding them for more convenient handling. Corundum is a very hard mineral of a light brown, blue, gray or black color; also the commoner adamantine spar, found chiefly in the Carnatic, near Alva, in China.

COSMORAMA.—A series of pictures or views generally seen through lenses and lighted with suitable lamps.

COSMORAMA STEREOSCOPE.—A stereoscope in which the lenses through which the picture is viewed are made nearly as large as the picture itself, and a portion cut off, so that the cartes can be brought to about three inches apart.

COTTON.—(Formula, $C_{36}H_{30}O_{30}$; molecular weight 486.)—A substance familiar to all in many states. Raw cotton consists almost of pure cellulose. In photography its principal use is in the manufacture of pyroxyline (*q.v.*). For this purpose it must be thoroughly combed and cleansed from all impurities. As it often contains oily matter, it is necessary to saponify this by boiling in a very weak solution of potash, and thoroughly washing and drying before treating with the acids.

COTTON, GUN.—See **Pyroxyline.**

COTTON WOOL.—Raw cotton. The hairs of the seeds of various species of gossypium, a very useful substance in the laboratory. A tuft placed in a funnel makes a convenient filter for collodion and other similar substances. Cotton or wool is used for the manufacture of gun-cotton and pyroxyline.

COVER-GLASS.—A piece of glass used to cover the film of a lantern slide or transparency.

COVERING POWER OR AREA OF ILLUMINATION of a lens is the amount of its image or practically the size of the plate it will cover. To find this the lens is fitted to a large camera so that the circle of illumination can be entirely seen on the ground-glass. The diameter of this circle should be not less than the diagonal measurement of the largest plate used. For instance,

the diagonal measurement of a whole plate 6½ x 8½ will be found to be 10½ inches, therefore the diameter of the circle of illumination should be not less than 11 inches. By measuring the diameter and drawing on a sheet of paper a circle equal in dimensions it is easy to find out the largest plates that can be covered. Thus if we have a circle of 16 inches we shall find that a 10 x 12 plate just comes within it and would therefore be completely covered by the image, but any size larger would protrude, and these parts would be bare glass in the negative and give black corners in the positive picture.

COWAN'S DEVELOPER.—A developer for gelatino-chloride plates, used chiefly for lantern slides and other transparencies. There are three formulæ by which differently-toned pictures can be produced. They are:

No. 1.—For Cold Tones.

Potassium citrate	136 grains
Potassium oxalate	41 grains
Hot distilled water	1 ounce

No. 2 —For Warm Tones.

Citric acid	120 grains
Ammon carbonate	60 grains
Cold distilled water	1 ounce

No. 3—For Extra Warm Tones.

Citric acid	180 grains
Ammon. carbonate	60 grains
Cold distilled water	1 ounce

To three parts of either of these add one part of the following previous to using:

Iron sulphate	140 grains
Sulphuric acid	1 drop
Distilled water	1 ounce

No. 1 is the quickest, No. 3 is the slowest developer. A variety of tones may be obtained by mixing the first and last developers.

CRACKED NEGATIVE.—A cracked negative should be printed from by placing the print at the bottom of a deep and narrow box, having blackened sides, and a sheet of tissue paper laid over the frame. No trace of the crack should then be visible. Another method is to suspend a board to a roasting-jack and upon this lay the frame so that it will be constantly revolving during the printing operation. If the glass only is broken, the film should be removed by immersion in a dilute solution of hydrochloric acid and then floated on to another glass plate.

CRAPE MARKINGS.—Peculiar markings of the appearance of crape, which sometimes make their appearance in the film of collodion in the wet-plate process. This defect is usually due to too great a specific gravity of the ether and alcohol employed. To the collodion should be added a quantity of an iodized collodion, made with absolute alcohol or ether, until the defect vanishes.

Crape markings also make their appearance in the collodion emulsion process, which may be due to the cause mentioned or to the fact of the bromide used being too coarse.

CRAWLING.—A term applied to the movement of the sensitized paper while in the printing frame. With many papers this effect often takes place on account of the contraction of the paper support or of the film itself. If the paper be slightly moist when placed in the printing frame, and then laid out in a warm place during the printing operation, the contraction or "crawling" will be so great as to give a blurred image. Some recent experiments proved that paper when moistened expanded in some cases as much as the eighth of an inch in a single sheet.

CRAYON.—Small cylinders of charcoal or of pipe-clay or chalk, colored with various pigments, which are used for drawing.

CRAYON ENLARGEMENT.—An enlargement executed with crayons. A photographic enlargement is usually made upon rough bromide enlarging paper, which acts as a guide for the artist to work upon. Or the enlargement may be properly done by photography, and crayons used only in retouching and adding the darker parts of the shading.

CREAM OF TARTAR (Formula $KHC_4H_4O_6$). Hydrogen potassium tartrate.—A salt obtained from tartar or angol. It is a gritty, white powder, sparingly soluble in water and insoluble in alcohol.

CREASES.—Creases in paper or pictures are often difficult of removal. The paper or picture should be laid face downwards upon a sheet of smooth unsized white paper. Cover it

over with another sheet of the same very slightly dampened, and then iron with a moderately warm flat-iron.

CREOSOTE, KREOSOTE or CREASOTE.—One of the numerous bodies found by Reichenbach in coal tar. It is a colorless liquid, and takes its name from its peculiar antiseptic properties. It has a strong empyreumatic odor, is slightly soluble in water, and readily in alcohol, ether, and glacial acetic acid. It coagulates albumen. Many of the derivatives of creosote, such as cresol, paracresol and phlorol, when mixed with potash, have a developing action upon bromide dry plates. Waterhouse is of opinion that the developing action is due to the presence of a small quantity of pyrocatechin or some homologous substance.

CRIBRIFORM.—A term applied to paper which has a number of intersecting diagonal lines like network, visible when viewed by transmitted light. This is produced by the frame of wire upon which the paper is laid in manufacturing. For the production of paper negatives these lines would, of course, be harmful. They can sometimes be removed by immersing the paper in a bath of dilute muriatic acid.

CRITICAL TEMPERATURE.—The temperature below which a substance may and above which it cannot be liquefied by pressure alone.

CROWN GLASS.—See **Glass.**

CRUCIBLE.—A melting pot of earthenware adapted to stand very high temperatures. A perfect crucible must withstand the highest temperature without fusion, and should be capable of bearing sudden changes of temperature without fracturing. It should also be incapable of being acted upon by the materials heated in it. Clay crucibles are made from a clay specially selected, and exposed in a moist state to the atmosphere for about three or four months. This process is termed weathering, and the clay becomes disintegrated, and the removal of foreign matter facilitated. It is then well beaten and mixed with the proper quantity of the refractory material. London crucibles are of a reddish brown color, and have a close texture. They do not stand sudden changes of temperatures well, but successfully the action of litharge. Graphite crucibles are of fine grain, and will stand the highest temperature possible, and will not fracture if subject to repeated sudden changes in temperature. Crucibles are also made of porcelain and platinum.

FIG. 143.
CRUCIBLE.

CRYSTAL.—A body more or less symmetrical in form, and commonly bounded by plane surfaces. Crystals of various substances may be formed by dissolving, or by fusing and allowing to cool gradually. The multitudinous forms of crystals have been distributed into six primary classes, distinguished from each other by the relative position of the three axes about which the planes or faces are arranged. These six crystalline systems are the following:

1. Isometric or Regular system.	The three axes equal and rectangular.
2. Tetragonal or Square prismatic system—two equal axes.	The three axes unequal and rectangular.
3. Orthohombric or Right prismatic system—all unequal.	
4. Hexagonal or Rhombohedral system.	Three axes equal at 60 degs., a fourth at right angles to the plane of the other 3.
5. Monoclinic or Oblique prismatic system—1 axis rectangular to 2.	
6. Triclinic or Doubly oblique prismatic system—none rectangular.	The three axes not equal and not rectangular.

CRYSTAL CUBES.—An application of the angle of total reflection of glass surfaces to stereoscopic purposes devised by Swan. The small photographs are taken in the usual way in a stereoscopic camera, and the combination of the two flat pictures so as to produce the true stereoscopic effect is managed by taking two rectangular prisms of glass ground to an angle of about 39 degs. to 40 degs. These two prisms are placed together with their widest sides in contact, or nearly so. One of the pictures is then attached to one side of the combination and the other behind. On looking at them the rays which reach one of the eyes are transmitted direct from the picture on the back of the glass; but the rays which reach the other eye are not from the back but from the side only, being reflected from the surfaces of the prisms where they touch. Thus it appears to be from the back also, and is made to coalesce with the other to give stereoscopic relief.*

CRYSTALHYDRATION.—The formation of a hydrate which is also a crystalline body.

CRYSTALLIN.—An albuminous substance found in the crystalline lens of the eye.

* Sutton's Dict. Phot.

CRYSTALLINE LENS.—A transparent solid body placed behind the iris of the eye. See **Vision.**

CRYSTALLIZATION.—The process of becoming crystallized. Most bodies which pass slowly from the liquid to the solid state tend to crystallize before the process is complete. If this action takes place with a solid body in the state of fusion crystallization is said to take place in the dry way. If, on the contrary, it is produced during the slow evaporation of a salt in solution, it is said to be effected by the moist method. Some bodies, as iodine, crystallize when passing from the gaseous to the solid state.

CRYSTALLOS.—A name given to a dry-plate developer compounded as follows:

Sodium sulphite cryst	8 ounces
Ferrocyanide potassium	2½ ounces
Hydrochinon	1½ ounces
Caustic potash solution (75 per cent.)	2 ounces
Distilled water	28 ounces

Dissolve the first three substances in 20 ounces of water, then add the caustic potash solution, finally rest of the water. The Paris crystallos is tinted with a red dye which has not, however, any action on the film, but is merely incorporated so that the development can be accomplished in weak daylight, provided sufficent of the developer be kept over the plate. Dilute the solution with from 1 to 5 and 8 volumes of water.

CRYSTALLOTYPE.—A name given to a photographic picture on glass.

CRYSTAL MARKINGS.—The formation of crystals and tree-like markings under the collodion film is due to the hyposulphite solution being improperly washed away. This defect will not make its appearance in some cases till many days.

CRYSTAL VARNISH,—See **Varnish.**

CUBIC CENTIMETRE (Symbol C.C. or C.C.M.)—A French liquid measure, equivalent to nearly 17 minims. See **Weights and Measures.**

CUMULOSE.—Full of heaps or lumps.

CUMULO-STRATUS.—A cloud resembling something between the cumulus and stratus.

CUMULUS.—One of the simplest forms of clouds. Cumuli clouds have the appearance of fluffy masses of cotton wool. They are more frequent in summer, and are best seen in the morning, as they have a tendency to lessen in bulk and vanish before the evening.

Cumuli clouds often give good effects to suitable landscapes. A few negatives should be made giving very rapid exposure.

CUP, DEVELOPING.—A cup for holding the developer is a convenient utensil, essential in the wet-collodion process, but practically unnecessary for the present dry-plate development. It should be preferably made of glass, or white stoneware, so that it can be kept clean. A small graduated glass measure is the best article for the purpose.

CUPRIC BROMIDE (Formula, $CuBr_2$; molecular weight, 223.4; synonym, copper bromide).—An exceedingly deliquescent substance very soluble in water and insoluble in alcohol. It is prepared by dissolving cupric oxide in hydrobromic acid and evaporating down the solution. It is used as an intensifier in the collodion process. Its action is to convert the silver image into insoluble silver bromide and cuprous bromide. The bleached image is next treated with a solution of silver nitrate when the cuprous bromide is converted into silver sub-bromide and cupric nitrate.

CUPRIC CHLORIDE (Formula $CuCl_2H_2O$. Molecular weight, 170.5. Synonym, *Chloride of Copper*).—An exceedingly deliquescent substance, soluble in alcohol. It can be prepared by heating copper in excess of chlorine, or in solution by dissolving copper oxide in strong hydrochloric acid, or by dissolving copper in aqua regia. It crystallizes in green prisms,

CUPRIC OXIDE.—See **Copper Oxides.**

CUPRIC SULPHATE.—See **Copper Sulphate.**

CUPRIC SULPHIDES.—See **Copper Sulphides.**

CUPROTYPE.—See **Copper Process.**

CUPROUS OXIDE.—See **Copper Oxides.**

CUPROUS SULPHIDES.—See **Copper Sulphide.**

CURVATURE OF THE FIELD.—In a photographic camera the image is thrown upon a plane screen; but, as will be seen by Fig. 144, the screen in order to receive the image should be of a concave form. The retina of the eye upon which the image is thrown is of a concave form, and for this reason we see all things straight. The effect of placing a plane screen is at once apparent. When we focus this image on the ground-glass in the centre the sharpness of the outer portions is destroyed, and if we bring the screen in a little, those outer portions become sharp, but the centre loses its distinctness. This is termed the curvature of the field of the image. This defect is greater with lenses of short focus than with lenses of long focus, and it is remedied to a very great extent by the use of the diaphragm. This subject is also dealt with under the headings **Diaphragm** and **Focus**, *q,v.*

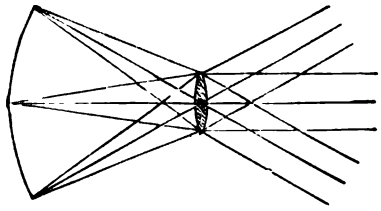


FIG. 144.—DIAGRAM SHOWING CURVATURE OF THE FIELD.

CUTICLE.—A thin skin or coating sometimes formed on the surface of a liquid.

CUT-OUT MOUNT.—See **Mount.**

CUTTING.—The cutting or trimming of the print may be done before or after toning. By trimming previous to the toning operation a slight saving in the gold is made, but the prints must be handled carefully to prevent the edges becoming torn or frayed. In cutting, the prints should be laid face upward upon a sheet of zinc or glass, a glass shape or cutting edge laid upon it, and the edges trimmed with a sharp knife or suitable cutter. Many of these are made, good, bad, and indifferent. For cutting out ovals it is necessary to have a cutter for the purpose, which is usually a sharp wheel revolving in two directions.

In cutting or trimming prints great care should be given to the proper position of the picture itself. Very often a fraction of an inch less foreground, and the same amount more sky, or *vice versa*, will make a wonderful difference in the appearance of the picture.

All cuttings and trimmings from paper or prints containing silver should be kept in one place, and when a large quantity of them has accumulated, it should be burnt in the open air, and the ashes either sent to a refiner, or the silver extracted in the manner given under **Residues.**

FIG. 145.—CUTTER.

CUTTING MOULDS.—Thick plates of glass cut to various sizes, and used in trimming prints.

CUTTING PLATES.—When it is necessary to cut a plate coated with a gelatine emulsion, first divide the film with a sharp penknife. The straight edge should be perfectly clean, or a piece of paper laid between it and the film. The knife must be perfectly sharp, otherwise the film will be dragged from the glass. The glass can then be cut without fear of the film leaving it. In cutting a number of plates, care should be taken that the chips and dust from the glass do not rest on the film, as pinholes and scratches would result.

CWT.—Abbreviation for hundredweight, C being the symbol for Lat. *centum*—a hundred, and wt. a contraction of "weight."

CYANIC ACID (Formula HC NO).—A colorless volatile liquid having a pungent, irritating odor.

CYANIDE.—A cyanide is a compound of the radical CN or Cy. It may be formed by dissolving a metallic oxide or hydroxide in a solution of hydrocyanic acid, H.CN, or by double decomposition of metallic salts with potassium cyanide, provided the resulting cyanide is insoluble. The cyanides principally used in photography are cyanide of silver, potassium and platinum Cyanides can be tested for, by the addition of silver nitrate to the solution. A white precipitate soluble in ammonia is formed.

CYANIDE OF PLATINUM.—See **Platinum Cyanide.**

CYANIDE OF POTASSIUM.—See **Potassium Cyanide.**

CYANIDE OF SILVER.—See **Silver Cyanide.**

CYANILIN (Formula, $(C_4H_5,NH_2)_2C_2N_2$).—A crystalline substance formed by the action of cyanogen on aniline.

CYANIN (Formula, $C_{29}H_{35}N_2I$. Molecular weight, 538. Synonym, *Chinolin Blue*).—

A dark blue powder dye. It is soluble in heated alcohol, but sparingly in water. It is used in orthochromatic photography to increase the sensibility of the silver bromide to the red end of the spectrum. It is sensitive to light so should therefore be kept in the dark.

CYANOGEN [Formula, $(NC)_2$].—First discovered by Guy Lussac. It may be prepared by heating perfectly dry mercuric cyanide in a hardened glass retort, when the cyanide will break up into metal and cyanogen, the latter coming off as a gas having a pungent and irritating smell. It is highly poisonous and burns with a beautiful violet flame.

CYANOGEN SOAP.—A soap containing cyanogen used for removing stains of silver nitrate from the hands.

CYANOSE.—Native sulphate of copper.

CYANOTYPE.—A process discovered by Sir John Herschell, about the year 1848. It is also known as the "blue process" owing to the color of the pictures. Owing to its simplicity in manipulation. the paper is largely used by draughtsmen and others for copying plans, maps, etc. Paper is coated with a mixture of ammonia, citrate of iron, (see **Ferric Ammonium Citrate**), and potassium ferricyanide. Upon exposure to light, this is changed into insoluble Prussian blue. The paper is exposed beneath a negative or a drawing, and cleared and fixed by simply washing the soluble parts away in water.

Since the process was made known by Herschell, very many improvements and additions have been made. They may be divided into three classes—*i.e.*, 1st, those giving white lines upon a blue ground; those giving blue lines upon a white ground; and 3d, those which give black lines upon a white ground.

White Lines upon a Blue Ground.—This process, which was the one devised by Herschell, is the simplest, although the effect is not so good for copying mechanical drawings. etc., as with the process giving blue or black lines upon a white ground. Very pretty blue photographs can, however, be obtained and for rapidly furnishing a proof from a negative there is no simpler process.

The solutions are made—20 parts of red prussiate of potash are dissolved in 100 parts of water, and 10 parts of ammonia citrate of iron in 60 parts of water. These two solutions should be mixed together immediately before using, and the operation must be performed in the dark. Paper is floated on this solution, and applied with a broad camel-hair brush, and then hung up to dry. If it is well dried and carefully preserved from light, moisture, and air this paper will keep for some time. After printing, which when sufficient should show the lines copied of a yellow color upon a blue ground, the prints should be washed in several waters, and if a few drops of chlorine water or dilute hydrochloric acid be added to the washing water the blue ground will appear much darker, and the lines rendered clearer and whiter. By this method the commercial paper sold is generally prepared. The prints may, if desired, be changed from blue to a weak black by immersing in a 4 per cent. solution of caustic potash until the blue is changed by the action of the potash to yellow. After being well washed they are laid in a 4 per cent. solution of tannin.

Converting Blue Prints into Brown Prints.—Blue ferro-prussiate photographic prints may be converted into brown prints by the following process:

The positive blue print, thoroughly washed and dried, is plunged into a solution of ammonia, in which it is kept until it has nearly or entirely lost its color. (The operation lasts from two to four minutes). The print is rinsed and plunged into a bath of tannic acid, the operation being stopped as soon as the desired sharpness and tone are obtained.

This last operation requires about ten minutes. If at the end of this time the color be not dark enough, it is intensified by adding to the bath a few drops of ammonia. After a lapse of one or two minutes, rinse in abundant water.

1.—Solution for Preparing the Sensitized Paper.

Tartrate of iron and potassium	15 Gm.
Red prussiate of potash	12 Gm.
Rain water	250 C.c.

2.—Solution to Remove the Color of the Print.

Stronger ammonia (0.900)	100 C.c.
Rain water	800 C.c.

3.—Solution to give the Brown Tone.

Tannic acid	10 Gm.
Rain water	500 C.c.

Dissolve and filter.

Vogel's method is thus described—10 parts of potassium ferric oxalate in 100 parts of water, and 10 parts of ferricyanide of potassium in another 100 parts of water. The remaining

operations are the same. With this method the red prussiate may be used in dilute form as a developer after exposure instead of being added to the mixture. Paper prepared without it can also be developed after printing in the usual way.

Another formula very commonly recommended is

A.

Citrate of iron and ammonia	2	ounces
Water	8	ounces

B.

Ferricyanide of potassium	1¼	ounces
Water	8	ounces

Mix equal parts immediately before use and float the paper upon it for three minutes, then dry.

If prints upon cyanotype paper be over-printed the following is a method of reducing them: The over-printed picture is laid in a weak solution of caustic potash until the lines become clear and the ground of a gray color. They are then immersed in a solution of hydrochloric acid, when it once more appears of a fresh blue color. It is then washed and dried in the usual way.

Prints which are too weak may be intensified by soaking them for five minutes in a solution of 1 drachm of ferric-chloride in 32 ounces of water and well washing them afterward.

Blue lines upon a White Ground.—In this process it is necessary the action of the light shall be to convert the iron compound into one that can be discharged from, instead of being fixed in, the paper, so that we obtain a positive from a positive. Abney describes the process as follows: Thirty volumes of gum solution (water five parts, gum one part) are mixed with eight volumes of a citrate of iron and ammonia solution (water two parts, double citrate one part), and to this is added five volumes of a solution of ferric chloride (water two parts, ferric chloride one part). This solution thus formed is limpid at first, but will gradually become thicker, and should be used soon after mixing. It is then applied with a brush to the paper, which should be well sized, and dried in the dark. Exposure is accomplished in a few minutes, the paper being placed under the drawing in the printing frame. It is then developed with—

Potassium ferrocyanide	50 grains
Water	1 ounce

applied with a brush until all the detail appears of a dark blue color. The print is then rapidly rinsed, and placed in a dish containing the clearing solution made of one ounce of hydrochloric acid and ten ounces of water.

Pellett's process is as follows; Paper is coated with boiled starch, so that the solution will remain on the surface and not sink into the paper. This is then floated on a solution of—

Chloride of iron	10 parts
Citric acid	5 parts
Water	100 parts

After drying, the paper is pressed flat and kept from light and moisture. The visible change in printing is very slight. A good plan to get the accurate exposure required is to place some few strips of the paper underneath another piece of paper, similar to the paper upon which the tracing or design from which you are printing has been made. One of these strips should be from time to time taken and placed in the developer, which is composed of a 24 per cent. solution of yellow prussiate. When these strips develop perfectly white the print has been sufficiently exposed. In direct sunlight one minute may possibly be sufficient, but on a dark or cloudy day half an hour, or an hour may possibly be necessary. After developing the prints are rinsed with water, washed with a dilute solution of hydrochloric acid, and again washed and hung up to dry.

Violet Black Lines on a White Ground.—The sensitizing solution required is composed of the following:

Water	16 ounces
Gelatine	4 drachms
Perchloride of iron (in a syrupy condition)	1 ounce
Tartaric acid	1 ounce
Sulphate of iron	4 drachms

The requisite exposure is about the same as with the last process. When sufficient the greenish yellow color will turn white except the lines, which should be somewhat dark. The developing solution is composed of one part of gallic acid in ten parts of alcohol and fifty of water. When immersed in this solution the lines will turn blacker. The finish is then made by thoroughly washing in water.

CYCLOGRAPH.—A panoramic camera constructed by Ross enabling one to photograph the whole or any desired portion of the circumference of a solid object, more or less cylindrical in form. It is used for photographing such objects as the drum of a recording instrument, or a vase decorated with paintings or reliefs.

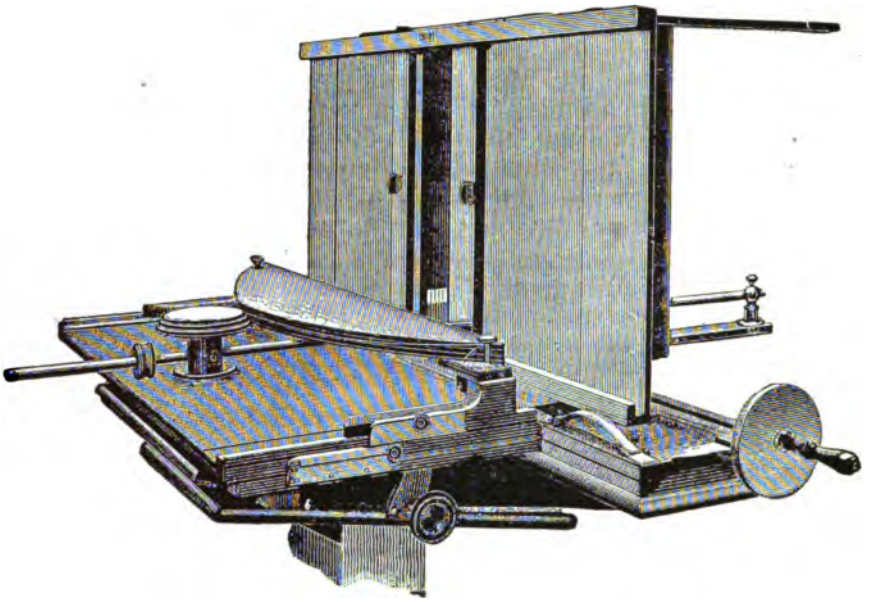


FIG. 146 —CYCLOGRAPH.

The principle employed is that of a cycloidal rotation. The object to be photographed is placed on a suitable turntable, and caused to travel across the axis of the lens in such a way that as it advances it also turns on its own axis, like a wheel in contact with a plane surface. At the same time a dark screen, in which is a narrow slit, travels on a parallel path, at a proportionate speed, in such a way that each successive point of the circumference of the object is exposed on the plate when it is at the cusp of a cycloid—*i.e.* when its movement is infinitesimal.

CYLINDER GLASS.—See **Glass.**

CYLINDRICAL LENS.—A lens whose curvature is that of a cylinder instead of a sphere. A cylindrical glass rod may be considered to be a cylindrical lens, although lenses of this kind are usually cylindrical one side and flat on the other. They bring the image of a source of light to a line instead of a point.

CYLINDROGRAPH.—A name given to a kind of panoramic camera (*q. v.*) capable of producing photographs embracing half the horizon.

DAGUERREOTYPE.—One of the earliest of photographic processes first published by Monsieur Daguerre in Paris, January, 1839. With this process a direct positive was obtained upon a silvered metal plate, sensitized by exposure to fumes of iodine in a dark chamber. The latent image was developed by fumes of mercury and fixed by hyposulphite of soda. A more detailed description of the process is as follows:

The first operation is to prepare the silver plate. These are usually made of copper, on which a film of metallic silver is deposited by one of the electro-plating processes. These plates may be purchased ready silvered, and only require polishing, but this must be very carefully done. First, for convenience sake, the corners should be clipped off about $\frac{1}{8}$th of an inch. The plate is then laid upon the work table, and four pieces of wood nailed round it to hold it firmly into position. The pieces of wood should not be quite as high, or at least should not be higher than the plate itself. A little powdered rottenstone or Tripoli powder in alcohol is then laid on, and worked about the plate with some Canton flannel. If the plate is very dirty it should be previously rubbed with dilute nitric acid. After the application of the Tripoli powder the plate is removed, and the back and sides cleaned. It is then returned to its former position, and is ready for polishing. This is done with a buff of the finest chamois leather, and some prepared charcoal or jeweller's rouge. The polishing should be done just before sensitizing, otherwise the polished surface is liable to attract impurities from the atmosphere In polishing rub well with the buff from side to side and from end to end alternately, but the last rub should be horizontally when looking at the picture.

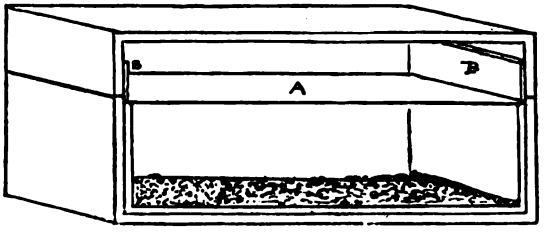


FIG. 147.

For sensitizing we require two boxes containing two compartments. Fig. 42 is an illustration of the one usually employed during the time when the Daguerreotype was practised for portraiture. Some iodine in powder is spread evenly over the bottom of the box at C. A is a piece of stout cardboard sliding into grooves, and B B are the supports upon which rests the

silver plate to be sensitized. First, the iodine will volatilise at an ordinary temperature, and condense on the underneath part of the cardboard. This is then reversed, and the iodine volatilises on to the plate, which gradually receives a thin coating of iodide. With this process the plate passes through many stages of color, and when it has arrived at a ruddy tint it is placed in another box similar to the one described and shown on Fig. 147, except that no piece of cardboard is required. At the bottom of this should be placed a mixture of bromine and calcium hydrate. This bromine is then allowed to attack the plate, and form with the iodide silver bromo-iodide. It will now assume a beautiful steel blue color, and at this stage is removed and returned to the iodine box, and again subjected to the iodine for about a third of the time formerly given. The plate is now sensitized, and is ready for exposure in the camera, which may be done at once, or it may be kept for several hours. After the last exposure to the bromine fumes the plate must be kept in the dark: should any white light reach it, however, by accident, it should be again subjected to the iodine vapor in the box.

The exposure is made in the well-known way. With regard to the time required, it of course, varies with the light and subject. If the picture be over-exposed, the lights become blue and solarized.

Development is effected with mercurial vapor. A tray made of cast-iron, and provided with wooden sides, a lid, and a thermometer, is required. Into the tray about a tablespoonful of mercury is filtered with a filter having a very small bore. The plate when removed from the camera has no visible image. It is now supported face downwards over the mercury, and the latter gradually heated to a temperature of 140 deg. to 150 deg. Fahrenheit. In a few minutes the image will be developed. The process can he watched by examining it from time to time in non-actinic light, and the development proceeded with until all the detail is properly visible. If the plate has been under-exposed the image will be weak and lacking detail, and if over-exposed it will be covered with a thin veil of mercury. In developing, if over-done, or if the mercury be over-heated, the shadows will be covered with fine specks, and if under-developed the lights will lack solidity, and the shadows detail. The box employed by Daguerre for mercurial development is shown in Fig. 148. It consists of a box mounted on legs, having a close-fitting cover, A, and an iron bottom, in which is placed the mercury C, with a small thermometer, F, to indicate the proper temperature. G is a piece of glass let into the side of the box, through which the Daguerreotype plate fixed in the frame, B, can be seen. D is the spirit lamp, and I the platform on which it stands. The cause of the change in development and the production of the image is due to the attraction the subiodide has for the metallic mercury vapor.

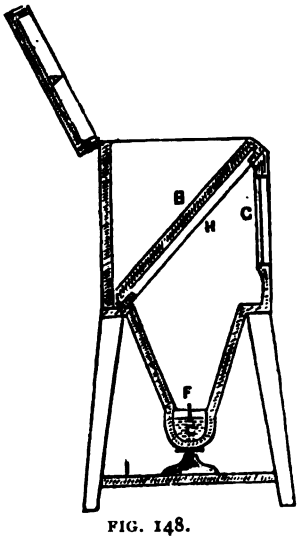


FIG. 148.

The next process is to fix the image. This may be done at once, or it may be left till a more convenient opportunity. Fixing is accomplished with a 10 per cent. solution of sodium hyposulphite in distilled water. In a few seconds the unaltered iodide, Ag_2I_2, and the Ag I of the subiodide will have been dissolved by the hypo, and the image will remain as a white amalgam of mercury and silver on a darker colored support.

The plate is then thoroughly washed in distilled water, and the appearance considerably improved with a hot toning solution, which darkens the silver, and gives a purer color to the amalgam. This solution is made with—

Gold bichloride	15 grains
Distilled water	2 ounces

and—

Sodium hyposulphite	60 grains
Distilled water	2 ounces

These two solutions are mixed together, and the plate is flowed over with as much of the solution as it will hold. With a spirit lamp placed underneath, the plate is gradually heated evenly all over by moving it continually over the flame until the toning action commences. After a few seconds the image will darken, and then gradually begin to clear up, the lights becoming whiter and the shadows darker. The more rapid the deposition of the gold the more satisfactory will be the resulting image. When it has attained a satisfactory stage the plate is well rinsed in a dish of cold water, and finally in distilled water. The plate is then dried in the following manner: Hold the plate by one corner, or, with suitable nippers, inclined at an angle of 45 deg. Pass it gently over the flame of a spirit lamp, beginning with the upper corner, and proceed to dry gradually downwards. As the fluid dries from the plate a line of wet gradually recedes till it reaches the edge, when it is removed with a piece of blotting paper. Should this method of drying be considered troublesome the plates may be dried spontaneously on a piece of blotting paper. Black spots which sometimes appear in drying may be removed with a dilute solution of potassium cyanide. This substance may be used to fix instead of hypo; it can also be used for

restoring the brilliancy of a faded Daguerreotype. The plate is now finished, and only requires placing and sealing up in the *passe-par-tout* to protect from dust and scratches.

DAGUERREOTYPES, ELECTROTYPING.—Daguerreotypes may be reproduced by electrotypy in the ordinary manner. The plate is immersed in the copper solution employed by electrotypers immediately after toning, and the usual manipulations carried out. The image of the Daguerreotype, although in relief, is naturally so to a very slight extent.

DAGUERREOTYPE, ETCHING.—A process of etching Daguerreotype plates by means of acid and a battery was introduced by Sir W. R. Grove. He immersed the plate in an aqueous solution 1 to 2 of hydrochloric acid; to the plate was attached a wire from the battery, and opposed to it was a platinum plate connected with the other pole of the battery, and placed at a distance of 2 inches from the Daguerreotype. A current was then sent through the circuit thus formed by a couple of Grove's cells. An oxy-chloride of silver was formed; at the end of thirty seconds the plate was sufficiently eaten away. The oxy-chloride was then removed, and for very delicate work the plate could be printed from in an ordinary printing press, great care being exercised. It is, however, a process far too delicate for everyday work, and has been completely abandoned.

DALLAS RUBBER-TYPE.—A method of making a photograph in caoutchouc or India-rubber, so that it will give prints in a press or with a hand stamp.

DALLASTINT.—A secret process of photo-mechanical printing invented by D. C. Dallas. It is exceptionally suitable for half-tone work, as it is a species of aqua-tint, capable of rendering fine detail and delicate gradation of tint. It is also used for decorative purposes by transfer to pottery, stone, wood, etc., and for printing on calico, linen, and other textile fabrics.

Chromo Dallastint.—An adaptation of the Dallastint process to color printing.

DALLASTYPE.—A secret process of photographic engraving for typographic printing, invented by D. C. Dallas.

DALTONISM.—See Color Blindness.

DAMMAR (Malay Damar).—A pale yellow or white resin obtained from the *Dammara Australis*, commonly known as the kawrie or cowdie pine in New Zealand, and the *Dammara alba*, Dammar pine, or cat's-eye resin of India. Dammar resin is also obtained from the Amborgna pine growing in the Malay Archipelago. It is largely used in the manufacture of varnishes, and is easily soluble in oil of turpentine, benzole, or chloroform. A dilute solution of gum dammar in turpentine makes a good retouching medium. See **Varnish.**

DAMP.—Moisture or dampness is a silent and secret enemy to the photographer. In a damp atmosphere nearly all the photographic preparations will suffer. It is, therefore, necessary to keep the chamber containing them in a dry state. This may be done by the application of heat in the damp weather, or by using calcium chloride, which effectually absorbs moisture from the atmosphere.

Damp walls are not conducive to longevity of silver prints hung against them. In such cases precaution should be taken to back the frames with good stout waterproof paper.

DARK ROOM.—The name given to the room in which all sensitive materials are handled. The term is somewhat erroneous, as it is not necessary that the room should be dark in a usual, but in a chemical, sense only. To explain this—We know that dry plates are very sensitive to light, but only certain rays of light are capable of making any change. We also know that a ray of white light passed through a prism can be broken up into a band of colors known as the spectrum band, and their order is always the same, *i.e.*, violet, indigo, blue, green, yellow, orange and red. The first are termed rays of high refrangibility, and those at the end, rays of low refrangibility. In photography we find that the change that takes place with sensitive plates is produced almost entirely by the rays of high refrangibility, the violet and blue having the most powerful effect, whilst the rays of low refrangibility, as yellow and red, have comparatively no effect whatever. The first are therefore termed actinic, and the last non-actinic.

It is this discovery which enables us to handle the sensitive plates in a room lighted only by non-actinic light without fear of spoiling them.

The question as to which is the best color for the light is a disputed one. It is evident that what we require is a medium which shall give the brightest possible light to work with, but will at the same time be perfectly non-actinic, and have no effect upon sensitive dry plates exposed to it for some time.

A little reflection will show that this depends to a great extent upon the sensitiveness of the material with which one operates. For instance, for the wet or dry collodion processes, gelatino-chloride plates, or paper, a canary-yellow glass will be sufficient protection from the actinic rays of daylight. For slow plates and for bromide enlarging two thicknesses of canary-

yellow medium will suffice; while for rapid gelatino-bromide plates a ruby-red glass will perhaps be necessary; although two thicknesses of orange paper should be sufficiently non-actinic for the most rapid plates, if they are not exposed to it for too long a period, as no light is absolutely safe, but will affect a gelatine dry plate if sufficient time be allowed it to act. The yellow glass is considered superior and safer than red, but it is necessary that precautions be taken to avoid using a yellow medium which will allow too much green light to pass through it.

Besides the quality of the light the quantity must also be considered. Daylight should never be recommended, as it is too variable. The window in the room should be blocked up with two or three thicknesses of brown paper, and artificial light employed. A large number of different dark-room lamps have been devised for this purpose.

The dark room should be as large as conveniently possible. It is a great mistake to suppose that any little closet or cupboard will suffice, and for those who require to be in it for

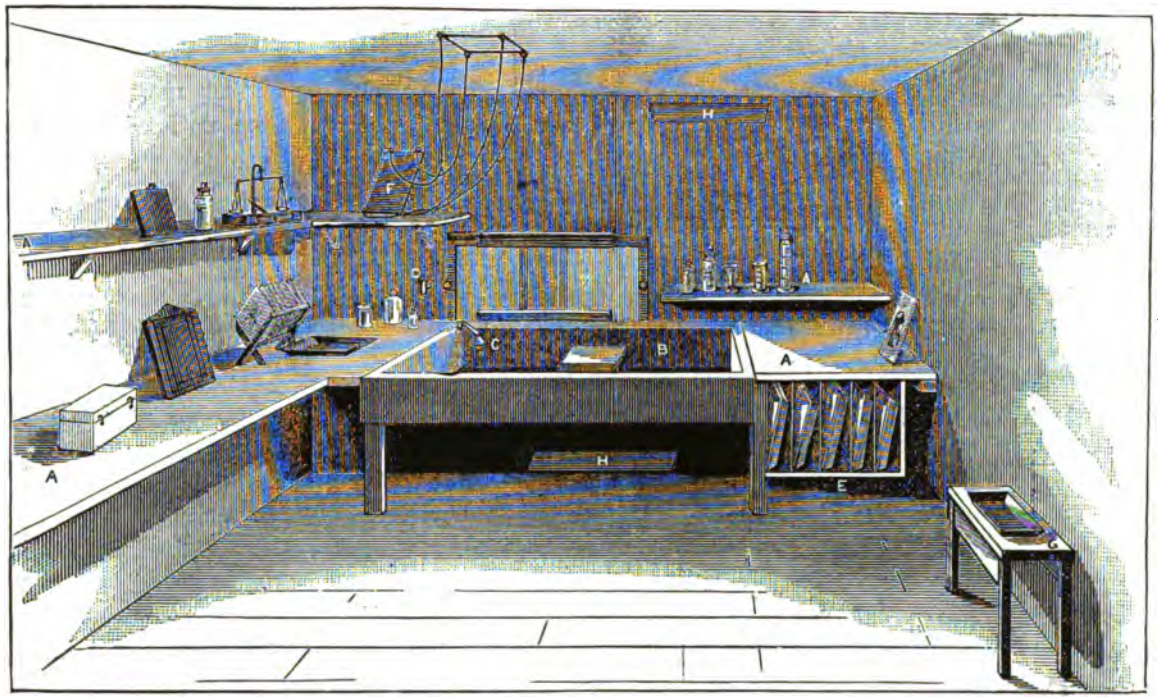


FIG. 149.—A, A, A, A, SHELVES; B, SINK; C, WATER TAP; D, GAS TAP; E, SHELF WITH PARTITIONS FOR DISHES; F, OSCILLATING TABLE; G, SMALL TABLE FOR HYPO. DISH; H, H, TRAPPED VENTILATORS.

prolonged periods it is extremely dangerous to their health. The room should be fitted with a sink having a tap above it, and several tables and shelves. Fig. 149 is a plan of a dark room with convenient fittings.*

Another important consideration is the ventilation of the room. It should be as lofty as possible, and an outlet for the vitiated air should be made in the ceiling or high up in one of the walls. It must be so arranged that it will let out the air without letting in light. Fig. 150 explains how this is done.

FIG. 150.

Besides this there should also be an inlet for the fresh air. This may be provided by piercing some holes at the bottom of the door and attaching a piece of wood outside in such a position, as shown in Fig. 151, as to prevent light from coming in, but without preventing the entrance of pure air.

The dark room should be kept perfectly clean, and everything cleared up and put into its proper place after every operation. Have a place for everything, and keep them all in their places.

DARK ROOM LAMPS.—See Lamps.

DARK SLIDE, The English term for the plate holder. It is also termed the single or double back. The double backs are the most convenient, as they carry two plates in but little larger space than required for one. The dark slide, usually made of wood or metal, must be perfectly constructed so as to be absolutely light tight. It should also fit easily in the grooves of the

* From "Work."

camera made to receive it; no jarring or sticking must take place. In a double dark slide two plates are placed with their sensitive faces outwards. They should fit exactly into the places provided for them and held firmly into position by means of catches. A piece of blackened tin or cardboard is placed between them to prevent the light passing through one and affecting the other. On both sides is a sliding shutter, which is either drawn up or right out before the plate is exposed, and returned to its position after exposure.

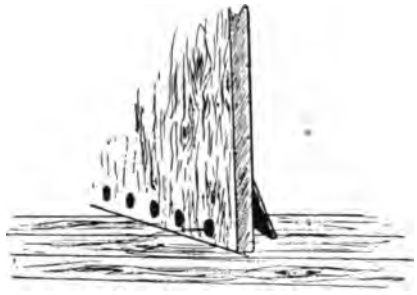


FIG. 151.

In some makes of dark slides spring catches are fitted to prevent the slides from being drawn out by accident, and others have the shutter hinged, so that when drawn up they fold back on to the top or side of the camera away from the wind and danger of being broken.

Cameras are usually provided with three double dark slides, but if a changing bag be employed one will be sufficient. The slides should be plainly numbered to prevent the same plate from receiving two exposures. To obviate this many arrangements have been devised by which the slide, when once drawn out and replaced, cannot be withdrawn a second time until another plate has been placed in.

Dark slides should be fitted with carriers if more than one size of plate is used. These are frames of blackened wood fitting into the space made for the plate, so that plates smaller than the ones the camera is intended for can be used. Carriers are also made for exposing films on negative paper.

DARK TENT.—A portable dark room used in the old days of the wet-collodion process, when it was necessary to develop the plate immediately after exposure. Similar arrangements are still constructed for the dry-plate process for the benefit of tourists, and are very convenient for changing the plates in the plate holders.

DAWSON'S PROCESS.—A collodion-emulsion process to which an organifier is added. The following are Dr. Dawson's formulæ:

COLLODION.

Pyroxyline	8 grains
Cadmium bromide	7 grains
Ammonium bromide	2 grains
Ether .725	½ ounce
Alcohol, 810	½ ounce

The collodion should be allowed a few days to settle; it is then decanted off.

To sensitize, the following mixture is made up:

Silver nitrate	13 grains
Acetic acid	2 drops
Glycerine	1 drachm
Alcohol, 830	4 drachms

This is then added to the collodion to form the emulsion, and, after standing for about a day, two drops of hydrochloric acid are added. It is again allowed a day to rest.

After this time the emulsion is poured out into a flat dish to allow the solvents to evaporate, which they will do in from five to six hours. The pellicular mass thus formed is then covered with water for one hour, and after pouring off it is covered for the same length of time with

Tannin	5 grains
Gallic acid	2 grains
Acetic acid	2 drachms
Distilled water	1 ounce

The pellicle is then washed until all traces of acid are removed. The water is then squeegeed out, and the emulsion dried in a hot water bath or spread out on blotting paper placed in a warm room.

The method of eliminating the water with alcohol is not possible with this emulsion, as it would dissolve the tannic and gallic acids.

To re-dissolve the pellicle for use take equal quantities of ether and alcohol of the same specific gravity as given. Dawson recommends soaking the pellicle in alcohol for twelve hours before adding the ether. A strong alkaline developer should be used.

DEAD BLACK.—A good dead black for brass work, interiors of lens mounts, diaphragms, etc., can be made by grinding four grains of lampblack on a plate with about six drops of gold size, or by stirring lampblack with Brunswick black varnish thinned with turpentine. Vegetable black and lacquer is also used. A substance is also sold under the name of enamelow. (q.v.)

DECANTATION.—The separation of a clear liquid from a precipitate or deposit. This is done by gently inclining the vessel and allowing the liquid to run out without disturbing the precipitate at the bottom. The glass should not be filled too full, or the liquid on inclining the vessel will run down the edge. If a wet glass rod be held in a nearly vertical position against the edge of the glass it will cause the liquid to run down it and fall into the lower vessel without splashing. Decantation is also effected by means of a syphon, there being less risk of disturbing the precipitate.

DECARBONISE.—To rid a substance of carbon.

DECIGRAMME.—The tenth part of a gramme. It equals .543234 grain.

DECILITRE.—A measure of volume according to the metric system. The tenth part of a litre. It equals 3 ounces, 4 drachms, 10·36 minims.

DECIMAL.—A tenth part. A decimal fraction is one whose denomination is 10 or some power of 10. It is not usual, however, to express this denominator, but a period called a decimal point is placed between the unit and the first fractional number; thus, 1.5 is the same as $1 + \frac{5}{10}$, or one and five-tenths. In like manner 1.05 means one and five hundredths; 1.673 signifies one unit six-tenths, seven-hundredths and three thousandths of the unit, and so on.

The value of a decimal of any denomination is found by multiplying it by the number of parts in the next less term, and cutting off as many places from the right hand as there are decimals, and continuing this until the terms are exhausted, thus .423 ounces is—

$$\begin{array}{r} .423 \\ 8 \\ \hline 3.384 \\ 60 \\ \hline 23.040 \end{array}$$

or a fraction over 3 drachms 23 grains.

DECIMAL SYSTEM.—A system of weights and measures in which the values of the different weights proceed by multiples of ten. (See **Weight** and **Measures.**)

DECIMETRE.—A measure of length according to the metric system. The tenth part of a metre. It equals 3.937 inches.

DECOCTION.—The operation of boiling. This term is also used to denote the liquid itself, which has been made to take up certain soluble substances by boiling.

DECOMPOSE.—*In chemistry*, to resolve a compound into simpler compounds or elements, as chloride of silver is decomposed by light, which resolves it into subchloride of silver and chlorine. *In optics*, to resolve or break up a beam of light into its constituent prismatic colors.

DECOMPOSITION OF LIGHT.—If a ray of white light be made to pass through a prism it is at once decomposed or separated into its constituent colored rays, which may, by means of another prism, be brought together again in the original form.

DECRIPITATION.—The crackling noise made by many substances when heated, their parts flying asunder.

DEFICATION.—The freeing from impurities.

DEFINITION.—In optics, the defining power of a lens, or, in other words, its accurate concentration of the rays of light from a point in an object to the corresponding point in the image, so that it be perfect in the most important detail without blurring. To obtain perfection in this respect the lens must be perfectly free from aberration (*q.v*).

DEFINITION, DEPTH OF.—See **Focus** and **Diaphragm.**

DEFLAGRATION.—A rapid combustion, attended with much evolution of flame and vapor.

DEFLECTION.—In optics, the deviation of a ray of light towards the surface of an opaque body.

DEKAGRAMME.—A measure of weight according to the metre system. It equals 0.3215 ounces troy.

DELIQUESCENT.—A solid is said to be deliquescent when it possesses the property of becoming soft or liquid by absorbing moisture from the air. Potash and calcium chloride are deliquescent.

DEMI-TINT.—A half-tint or medium shade of color.

DEMY.—Paper of a particular size. (See **Paper.**)

DENSITY.—If two bodies have equal bulk, but one contains more matter than the other, it is said to have greater density; or, if two bodies contain the same quantity of matter, but one of different bulk, then the body which is of less bulk is of greater density than the other. Thus density is directly proportional to the quantity of matter, and indirectly proportional to the bulk. Lithium is the least dense metal known; taking water as unity its density would be 0.59. Iridium is the densest, it being 2.24 times denser than water. The density of the ordinary metals is in the following order :—Aluminium, antimony, zinc, iron (wrought), copper, bismuth, silver, lead, gold, platinum.

In the manufacture of lenses the density of the glass employed determines the curvative requisites in making a lens with a definite focus.

The term density is also employed in photographic language to signify opacity. A perfect negative shonld possess correct density, which is proved in the printing process. If the density of the negative be just sufficient as to allow the detail in the high lights to impress itself upon the print it is correct. The density or opacity of the negative depends upon the amount of metallic silver deposited, and it is in the knowledge of when to stop development to obtain the right density that the success of developing lies. Several instruments have been constructed for the measurement of the density of negatives. Among these may be mentioned Captain Abney's and that of Messrs. Hurter and Driffield. With the first instrument Captain Abney's investigations show that the logarithm of the amount of silver on the plate is proportional to the square root of the logarithm of the opacity, the inverse of the transparency. Messrs. Hurter and Driffield's instrument is a much simpler affair, as no calculations are required, a number being read off the instrument proportional to the amount of silver on the plate.

In the collodion process a lack of density is caused by the collodion being too thin or by an insufficient sensitizing in the silver bath, or by too weak an alkaline developer (*q.v.*). With gelatine plates want of density may be caused by the emulsion. Too great a density may also be met with in a reducing agent. See **Reducer.**

DEODORIZER.—Any substance which has the power of destroying fœtid or noxious effluvia, chloride of lime, carbolic acid, etc., are excellent. See **Disinfectant.**

DEOXIDATION.—The abstraction of oxygen. See **Reduction.**

DEPTH OF FOCUS.—See **Focus.**

DESICCATION.—The evaporation, or drying off, of the aqueous portions of bodies. It may be done by exposure to the sun, by a current of dry air, or by many other devices.

DESK.—See **Retouching Desk.**

DESTEMPER.—See **Distemper.**

DESTRUCTIVE DISTILLATION.—Dry distillation. The heating of non-volatile organic bodies in a retort. See **Distillation.**

DETACHABLE FRONTS.—An arrangement in the camera for quickly changing one lens for another. The center of the front is made detachable, being secured into light-tight position by small clamps. Each lens is attached to a different front, and, as they all fit in the same place, any one can be put in as required.

DETAIL.—A minute or particular part of the negative, or picture therefrom, as distinguished from the work as a whole. The negative, or picture, is said to possess detail when these parts are sharply or clearly defined. The introduction of the diaphragm gives more detail to the image at the sacrifice of the light, and necessitating increased exposure.

DETECTIVE CAMERA.—See **Camera.**

DETERGENT—Any substance possessing the property of cleansing. Alkalies have the power of dissolving both soap and grease, hence both are used as detergents. For cleansing glass the agents used are generally Tripoli powder, ammonia, alcohol, caustic soda, potash and diluted acids. A solution of potassium dichromate and sulphuric acid is an effective cleanser, although the use of acids is always open to objection. Cyanide is also a very good detergent, although highly dangerous to use. A glass can usually be rendered perfectly clean by rubbing well with a rag dipped in a cold solution of caustic potash, and then immersing it into a dilute solution of nitric acid, and giving it a thorough washing afterwards.

DEVELOPER.—The agent which builds up, or otherwise renders visible, the latent image. When the plate is exposed on the camera no visible change takes place, but some of the particles have been affected by the light, whilst others remain as they were. The action of the developer may

be merely to change the color of these light-affected particles, and render them visible to the eye; or it may be to build up an image upon those which have been altered. In general terms, the developer may be described as the agent which exerts an action upon those portions of a sensitive compound which have been exposed to the light in a different manner to that which it has upon those parts which have not been so exposed. The two principal developers are the pyrogallic acid and the ferrous oxalate. In the first the reducing action of the pyrogallic acid is assisted with an alkali, such as ammonia, and in the second we have the ferrous oxalate as the reducer.

Alkaline pyrogallic development is, perhaps, the one chiefly used for developing gelatino-bromide dry plates. If we take a dry plate and expose it to the light, we have a certain quantity of silver sub-bromide. If the plate be then immersed in a solution of plain pyrogallic acid, scarcely any perceptible change will take place, but if a small quantity of an alkali, such as ammonia, be added, the plate will instantly blacken, forming metallic silver. The action that is supposed to take place is this: The silver bromide is split up into silver and bromine, which is immediately laid hold of by the ammonia to form ammonium bromide, and possibly other complex compounds, and the oxygen of the ammonia combines with the pyrogallic acid, causing some immediate actions to take place. The whole theory of the latent image and development is wrapped up in apparently unfathomable obscurity. Many theories have been put forward by able scientists, differing considerably from one another.

With the ferrous-oxalate developer the action is somewhat similar to the alkaline. This method of development was introduced almost simultaneously by Carey Lea and W. Willis, Jun. The oxalate of potash should be neutral, and the iron sulphate slightly acid. When saturated solutions of these two chemicals are added together in the proportions of one of iron to three of potash the following change takes place:—$FeSO_4 + K_2C_2O_4 = FeC_2O_4 + K_2SO_4$. The ferrous oxalate is the developing agent; the potassium sulphate is useless, and has apparently no action whatever upon the plate. If much more iron be added than the proportion given a larger quantity of ferrous oxalate will be formed than the solution will hold, and it will fall as a yellow precipitate, rendering the developer useless.

The action of this developer upon the silver bromide is a little clearer if the following accepted theory be correct:—$3(Fe, C_2O_4) + 2Ag_2Br = Fe_2, (C_2O_4)_3 + FeBr_2 + 4Ag$; or, in plainer language, ferrous oxalate and silver sub-bromide give ferric oxalate, ferrous bromide, and silver. With the development it will be seen that ferric salts are produced. These have a directly opposite action to the ferrous salts, so that the developer rapidly loses its strength.

If an old developer be exposed to light the ferric oxalate will become decomposed into ferrous oxalate and carbonic anhydride, thus, $Fe_2 (C_2O_4)_3 + 2FeC_2O_4 + CO_2$. Owing to the non-actinic color of the solution the action of the light is slow; the bottle should be occasionally shaken up. This old developer can then be used to start the development of an exposed plate, adding fresh developer afterwards to give strength to the image. Old developers may also be regenerated by the addition of zinc, which abstracts from the iron the bromine that it has taken during development. $2FeBr_3 + 2Fe_2(C_2O_4)_3 + 3ZnBr_2 + 6FeC_2O_4$. The non-actinic color of the ferrous oxalate developer allows of a little brighter light being used in the dark room during development.

Many other kinds of developers, such as hydrokinone, hydroxylamine, eikonogen, acetate, phosphate, lactate of iron, etc., etc., are used. Some thousands of different formulæ have been given. The most important are the following:—

Pyrogallic Developer No. 1.

Solution No. 1.

Pyrogallol	50 grains
Sodium sulphite	200 grains
Sulphuric acid	6 minims
Distilled water to make	1 fluid ounce

Solution No. 2.

Liquor ammonia .880	1 ounce
Distilled water	9 ounces

Pyrogallic Developer No. 2.

Solution No. 1.

Pyrogallol	1 ounce
Citric acid	½ ounce
Water (distilled) to make	9 ounces

Solution No. 2.

Potassium bromide	1 ounce
Water to make	9 ounces

Solution No. 3.

Ammonia .880	1 ounce
Water to make	10 ounces

To make up, take for every ounce of water twenty minims of No. 1, twenty to forty of No. 2, which acts as a restrainer, and twenty to forty minims of No. 3, according to the exposure of the plate.

Pyrogallic Developer No. 3.

Solution No. 1.

Potassium carbonate	1 ounce
Sodium sulphite	2½ drachms
Distilled water	5 ounces

Solution No. 2.

Pyrogallic acid	3½ drachms
Sodium sulphite	6 drachms
Citric acid	½ scruple
Distilled water	5 ounces

For developing, take 6 parts of each solution, and add 60 parts of water.

Pyrogallic Developer for Isochromatic Plates.

Solution No. 1.

Pyrogallic acid	1 ounce
Methylated alcohol	7 ounces
Glycerine	½ ounce

Solution No. 2.

Potassium bromide	60 grains
Distilled water	7 ounces
Ammonia .880	1 ounce

To develop, add one part of No. 1 to fifteen parts of water, and in another bottle mix one part of No. 2 with fifteen parts of water. The dilute solution should be made fresh every day.

Pyrogallic Developer for Films.

Solution No. 1.

Pyrogallic acid	80 grains
Bisulphite of potash	80 grains
Water	20 ounces

Solution No. 2.

Liquor ammonia .880	2 drachms
Ammonium bromide	20 grains
Water	20 ounces

Dissolve the bisulphate in the water, and add the pyro. For development, mix equal parts of the two solutions together, adding more of No. 2 if necessary.

Pyrogallic Developer for Bromide Lantern Plates.

Solution No. 1.

Pyrogallic acid	40 grains
Meta bisulphite of potash	120 grains
Distilled water	20 ounces

Solution No. 2.

Liquor ammonia	2½ drachms
Ammonium bromide	40 grains
Distilled water	20 ounces

Take equal parts for development; which, with this developer, proceeds slowly.

Stolze's Pyro Developer.

Solution No. 1.

Neutral sulphite of soda	1 ounce
Pyrogallic acid	3 drachms
Sulphuric acid	3 to 4 drops
Water	4 ounces

Solution No. 2.

Potassium carbonate	3 ounces
Neutral sulphite of soda	6 drachms
Water	7 ounces

For use take three parts of each solution in 100 parts of water. Citrate or bromide of potassium can be used as a restrainer.

FERROUS OXALATE DEVELOPER NO. 1.

SOLUTION NO. 1.

Water	30 ounces
Potassium oxalate	10 ounces

SOLUTION NO. 2.

Water	30 ounces
Iron sulphate	10 ounces
Tartaric acid	2 drachms

SOLUTION NO. 3.

Ammonium bromide	1 ounce
Water	10 ounces

For use take one part of No. 2 and add it to four parts of No. 1; a few drops of No. 3 are then added. This last solution acts as a restrainer. If the plate be over-exposed add from 10 to 20 drops.

FERROUS-OXALATE DEVELOPER NO. 2.—ONE SOLUTION FORMULA.

Neutral potassium oxalate	5 ounces
Ferrous sulphate	2 ounces
Citric acid	100 grains
Boiling distilled water	20 ounces

This solution to be diluted when required for use with about three times its volume of water.

FERROUS-OXALATE DEVELOPER FOR ISOCHROMATIC PLATES.

Neutral oxalate of potash	10 ounces
Distilled water	35 ounces
Protosulphate of iron	7 drachms
Distilled water	4 drachms
Sulphuric acid	2 to 3 drops

FERROUS-OXALATE DEVELOPER FOR FILMS.

SOLUTION NO. 1.

Oxalate of potash	16 ounces
Hot water	48 ounces

Acidify with sulphuric acid.

SOLUTION NO. 2.

Protosulphate of iron	16 ounces
Hot water	32 ounces
Sulphuric acid	½ drachm

SOLUTION NO. 3.

Bromide potassium	1 ounce
Water	32 ounces

When cold take six ounces of No. 1, one ounce of No. 2, and ten drops of No. 3, and add together in the order named.

FERROUS-OXALATE DEVELOPER FOR CHLORIDE PLATES AND PAPER, OPALS, ETC.

SOLUTION NO. 1.

Potassium citrate	200 grains
Potassium oxalate	60 grains
Water	1 ounce

SOLUTION NO. 2.

Iron sulphate	80 grains
Sulphuric acid	1 drop
Water	1 ounce

For use take equal parts of No. 1 and No. 2. (See also Cowan's developers.)

FERROUS-OXALATE DEVELOPER FOR BROMIDE PAPER.

SOLUTION NO. 1.

Neutral oxalate potash	1 pound
Citric acid	1 drachm
Hot water	50 ounces

SOLUTION No. 2.

Protosulphate of iron	15 ounces
Citric acid	1 drachm
Hot water	30 ounces

SOLUTION No. 3.

Potassium bromide	1 ounce
Water	20 ounces

For normal developer add to 6 ounces of No. 1, one ounce of No. 2. and 6 drops of No. 3. Mix in the order given and immediately before required for use.

HYDROKINONE DEVELOPER FOR CHLORIDE PLATE OR PAPER.

SOLUTION No. 1.

Hydrokinone	6 grains
Water	10 ounces

SOLUTION No. 2.

Potassium carbonate	
Water to make sat. sol.	

SOLUTION No. 3.

Sodium chloride	20 grains
Water	1 ounce

To each ounce of No. 1 add half a drachm of No. 2 and four drops of No. 3.

HYDROKINONE DEVELOPER FOR BROMIDE PLATES OR PAPER.

SOLUTION No. 1.

Hydrokinone	6 to 12 grains
Water	1 ounce

SOLUTION No. 2.

Ammonium carbonate sat. sol.

To each ounce of No. 1 add one drachm of No. 2.

HYDROXYLAMINE DEVELOPER FOR CHLORIDE PLATES OR PAPER.

SOLUTION No. 1.

Hydroxylamine hydrochloride	20 grains
Alcohol	1 ounce

SOLUTION No. 2.

Potassium carbonate	6 drachms
Water	1 ounce

SOLUTION No. 3.

Ammonia .880	1 drachm
Water	1 ounce

For sepia brown tones take half a drachm of Solution 1, forty minims of Solution 2, and one ounce of water. For chocolate tints add one minim of Solution 3 to the above. A somewhat bluer image is obtained by adding half a drachm of Solution 3 and half a drachm of Solution 1 to an ounce of water.

BEACH'S POTASH DEVELOPER.

SOLUTION No. 1.

Distilled water (hot)	2 ounces
Sodium sulphite	2 ounces

When cold add—

Sulphurous acid	2 ounces
Pyrogallol	½ ounce

SOLUTION No. 2.

Potassium carbonate	3 ounces
Sodium sulphite	2 ounces
Water	7 ounces

Dissolve separately and mix. For development of a correctly exposd plate take equal parts of both solutions and add eight times its volume of water. For an under-exposed plate use more potash solution, and less if over-exposed.

Ferrous-Sulphate Developer for Collodion Process.

Ferrous sulphate sat. sol	2 ounces
Glacial acetic acid	½ ounce
Alcohol	1 ounce
Water	16 ounces

This developer is also known as Wortly's. (See also collodion processes).

Soda Developer.

Solution No. 1.

Pyrogallic acid (dry)	3 grains

Solution No. 2.

Sat. sol. dry monocarbonate of soda	1 drachm

Solution No. 3.

Potassium bromide sol. (2 per cent)	1 to 20 minims

Solution No. 4.

Water	2 ounces

Dissolve Nos. 2 and 3 separately, and add together with the pyro to Solution 4.

Soda Ammonia Developer.

Water	1 ounce
Pyro	2 grains
Ammonium bromide	1 grain
Common Washing Soda	100 grains
Ammonia	1 minim

Make up the pyro and the ammonia in the form of 10 per cent. solutions, and add the ammonia during development as required.

Eikonogen Developer.

Distilled water	50 ounces
Sodium sulphite	2½ ounces
Sodium carbonate	1½ ounces
Potassium carbonate	½ ounces
Eikonogen	½ ounces

Hydrokinine and Eikonogen Developer.

Solution No. 1.

Distilled water	10 ounces
Hydrokinone	1 drachm
Eikonogen	1 drachm
Potassium meta-bisulphite	1 drachm

Solution No. 2.

Distilled water	10 ounces
Potassium carbonate	5 drachms
Sodium carbonate	5 drachms
Ferrocyanide of potassium	5 drachms

Para-amidophenol Developer.

Para-amidophenol hydrochlorate	150 gr
Sulphite sodium in crystals (Andresen's)	1½ ounces
Potassium carbonate	1½ drachms
Water	32 ounces

May be diluted in the proportion of from 1:8 to 1:12.

Rodinal.

Metabisulphite of postassium	30 Gm.
Para-amidophenol hydrochlorate	10 Gm.
Potassium hydrate	To neutralization.
Water	100 Gm.

This developer permits of being diluted in the proportion of 1:40.

Metol Developer (Hauff).

Solution A.

Water	100 parts
Metol	1 part
Soda Sulphite	20 parts

SOLUTION B.

Water	100 parts
Carbonate potash (or substitute)	10 parts
Crystallized carbonate soda	20 parts

For use, three parts A to one of B, with 40 mimims of bromide of potassium solution (1:10).

METOL DEVELOPER (ANDRESEN).

ONE SOLUTION.

Water	1 quart
Metol	¾ ounce
Sulphite of soda	7 ounces
Carbonate of potash	3½ ounces
Bromide of potassium	1/10 ounce

TWO SOLUTION.

A.—Water	1 quart
Metol	¾ ounce
Sulphite of soda	7 ounces
B.—Water	3 quarts
Carbonate of soda	7 ounces

Of these, one part of A is mixed with three parts of water for use, bromide of potassium being added as required for the prevention of fogging.

AMIDOL DEVELOPER.

Dissolve 10 ounces of neutral sodium sulphite in crystals (Andresen's) in 50 ounces of distilled water, and add 1 ounce of amidol. Dissolve, filter quickly, and fill up in small bottles.

For use, dilute with from 2 to 4 volumes of water.

Do not spare bromide of potassium.

CRYSTALLOS.

Sodium sulphite cryst	8 ounces
Ferrocyanide potassium	2½ ounces
Hydrochinon	1½ ounces
Caustic potash solution (75 per cent.)	2 ounces
Distilled water	28 ounces

Dissolve the first three substances in 20 ounces of water, then add the caustic potash solution, finally the rest of the water. The Paris crystallos is tinted red with aniline dye, which, however, has no influence upon its action.

Dilute the solution with from 1 to 5 and 8 volumes of water.

GLYCIN DEVELOPER.

Sodium sulphite	40 grains
Glycin	20 grains
Potassium carbonate	80 grains
Water	4 ounces

For developers for collodion, platinotype and other processes, see under their respective names.

DEVOLOPING TENT.—A tent composed of a non-active material, and so constructed that the operations of developing, etc., can be carried on by the operator without the necessity of a dark room. Fig. 151 shows the construction and use of a convenient developing tent.

DEVELOPING TUBES.—Glass tubes with closed ends, one containing pyro and the other ammonia. They are made for the convenience of tourists. When required for use the ends are broken off and the solutions mixed with the proper quantities of water.

DEVELOPMENT.—The process of rendering the latent image visible by means of a suitable agent. Under developer we have a large quantity of formulæ, and we have under this heading to describe the method of applying to the exposed plate.

Before proceeding to develop it is almost essential that the operator should have some knowledge of the plate about to be developed. If he has himself made the exposure he will generally be able to tell whether the error in exposing, if there is likely to be one, will be in under or over exposure. For this he will be guided principally by the subject itself. The developer is then mixed up accordingly. In all developers we have an accelerator and a retarder, and the careful and judicious arrangement of these solutions is one of the secrets of success in development.

It must not, however, be imagined that a short exposure in the camera can be righted by

prolonged development. There is a certain time necessary for the formation of the invisible image, which can only be shortened or lengthened to a very limited extent. With the pyrogallic acid developer more latitude is allowed; with ferrous oxalate very little.

The exposed plate in the dark slide is removed to the dark room, and there it remains until the developing solutions have been made up and are perfectly ready. With each make of plate is usually given the formula for development most suitable, and as this is usually the result of careful investigation of the various formulæ it should be carried out wherever possible.

The following method of developing with pyro and ammonia serves well with almost every kind of dry plate: Take about four grains of dry pyro and 1½ ounces of water. This quantity is sufficient for a half-plate; for larger sizes multiply proportionately. Dissolve the pyro in the water, place the exposed plate in the developing dish, and flow the solution over it. To the pyro should be added a small quantity of a restrainer. With a soft camel-hair brush then remove all air-bubbles or foreign matter from the surface of the film. Into a clean measure next place about two drachms of a ten per cent. aqueous solution of ammonia, and pour into this the pyro solution from the developing dish. Next return the whole solution to the dish by flooding the plate quickly and evenly. The dish is then gently rocked, causing the developer to flow backwards and forwards.

FIG. 151.—DEVELOPING TENT.

After the space of one minute if no image appears pour another drachm of the ammonia solution into the measure, and pour on to it the developer from the dish, again flood the plate with the strengthened solution, and continue the rocking motion. If the plate has been correctly exposed the image should now make its appearance, the high lights coming up first. If not, another quantity of the ammonia solution must be added in the same manner as described, and the solution returned to the dish. The image will now gain in density and opacity, and it should be examined from time to time by the light of the lamp. The back should also be examined for the appearance of the high lights. When the required density is obtained, which is only arrived at by practice, the plate is removed from the developer and thoroughly rinsed in water. This done, it is removed to the fixing bath.

The process of development is one that requires considerable care and attention, and it is only by practice and patience that success is arrived at. To develop a plate which has received the correct amount of exposure to light is a comparatively easy matter, but to develop and make good printing negatives from plates which have been either under or over-exposed is where the skill of the operator is taxed to the utmost.

For beginners the ferrous-oxalate developer offers many advantages, although it possesses one drawback: *i.e.*, there is less control to be had over it than with the pyro developer, and therefore it is almost essential that the exposure be correct, otherwise the method is a very simple one. Stock saturated solutions are made of potassium oxalate, iron sulphate, and ammonium bromide. To the iron a small quantity of tartaric or sulphuric acid is added to preserve. For developing we pour into a glass measure four ounces of potash solution, and add to it one ounce of the iron and three or four drops of ammonium bromide. Dilute the whole with an equal quantity of water and flood over the plate. If the image appears too quickly (the result of over-exposure) about 20 drops of the ammonium bromide restrainer must be added to the developer. If, on the contrary, the image is slow in appearing, a little more of the iron solution may be added. If too much be taken, however, a yellow precipitate of ferrous-oxalate will be formed, and the developer spoilt. With this developer the image should be allowed to get much darker than with pyro, as the density is very deceiving, and becomes much lighter when placed in the fixing bath.

DEVIATION.—A term used in optics to denote the alteration of the course of a ray of light when it is reflected or refracted from its direct course.

DEVITRIFICATION.—The process by which glass loses its characteristic vitreous properties, and becomes opaque. The change can be produced by slow cooling, or by prolonged heating.

DEXTRINE.—(Formula, $C_6H_{10}O_5$; molecular weight, 162.)—A substance made by heating starch paste to about 170 to 200 deg. C. until it loses its gelatinous property. Also by the action of boiling dilute sulphuric acid on starch paste, and afterwards neutralizing with chalk. If boiled for a longer time the dextrine is converted into dextrose.

Dextrine is a gummy, amorphous mass, soluble in water, and precipitated by alcohol. It takes its name from its dextro-rotatory action on polarized light. It is very largely used as a substitute for gum, and it is known also by the names of British gum, starch gum, etc. It is used as a mountant for photographic prints, but should be carefully separated from acid before using, as this would be destructive to all kinds of silver prints. See **Mountant.**

DEXTROSE.—(Formula, $C_6H_{12}O_6$.: synonym, *grape sugar*, *dextro-glucose*; etc.)—Occurs in grapes and other sweet fruits, also in honey. It can also be produced by boiling starch with dilute sulphuric acid for several hours. The solution is then neutralized with chalk, filtered, boiled with animal charcoal, to remove traces of color. The whole is then evaporated to dryness, forming an amorphous mass containing about 60 per cent. of dextrose, the remainder being chiefly dextrine.

DI.—A prefix expressing "double," twice. In chemistry the prefix di is now used instead of bi, as dichloride of mercury, dichromate of potassium, etc.

DIACTINIC.—A term applied to any medium which allows both the actinic and non-actinic rays of light to pass through it. Substances which allow only non-actinic rays of light to pass are termed adiactinic.

DIALYSER.—The parchment paper or septum stretched over a wooden ring, and used in the process of dialysis. A similar arrangement is sometimes used in the emulsion process for washing the gelatine emulsion. It may be constructed as follows: Take a box having a tight-fitting lid; knock out the top and bottom, and stretch over one end a piece of parchment paper, fitting the rim of the lid over it to keep it tightly into position. This arrangement is then allowed to float on water. The substance to be dialyzed is poured on to the septum, when diffusion immediately takes place, the crystallized elements passing through and being dissolved in the pure water, while the colloid remains behind. In the case of emulsions the unnecessary salts, such as nitrate of soda, etc., pass through the septum, leaving the colloid gelatine holding the sensitive silver salts behind.

DIAMETER.—A line drawn passing through the centre of a circle, or other curvilinear figure, and terminating each way at the circumference.

Given the diameter of a circle, multiply it by 3·1256 to obtain the circumference, and *vice versa*.

To obtain the area of the circle, square the diameter and multiply by ·7854.

To obtain the solid contents of the sphere, multiply the cube of the diameter by ·5236.

DIAMIDOPHENOL.—See **Amidol.**

DIAMOND.—A small piece of diamond mounted in a handle, and used for cutting glass. The extreme point of any diamond will scratch glass, making a white streak, but when the rounded edge is slid over a sheet of glass with a light pressure it will produce a cut which, although scarcely visible, will speedily extend through the whole. The irregular octahedrons with round facets are the most suitable for cutting glass.

DIAMOND CEMENT.—Soak a small quantity of isinglass in cold water until soft, then dissolve it in the smallest quantity of proof spirit by gently warming. In half ounce of this dissolve 20 grains of ammoniacum, and while still liquid, add a solution of 2 drachms of rectified spirit; stir them well together, and place in covered bottles. When required for use, stand the bottle in hot water till the solution liquefies.

DIAMOND LENS.—A lens made with a diamond. It possesses very high refractive and small dispersive power, and consequently requires much less curvature than glass lenses of the same focal length.

DIAPHANOUS.—Transparent, translucent.

DIAPHANOSCOPE.—A dark box for exhibiting transparent pictures with or without a lens. The positive should be placed in the box at a distance from the eye equivalent to the focal length of the lens with which the negative was made.

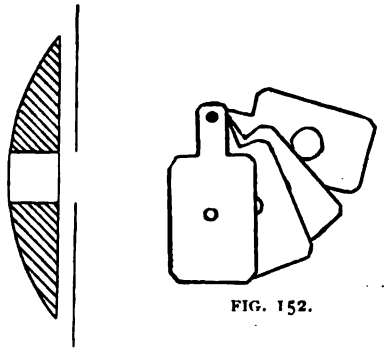


FIG. 153.

FIG. 152.

DIAPHRAGM.—These are metal plates, with a hole in the centre of different diameters, ranging in geometrical proportion to the focus of the lens to which they belong. Fig. 152 shows the form in which they are usually made. Each plate is made to slip in front of or between the combination of the lens, and obstruct the transmission of the marginal rays, and allow only those to enter which are parallel to the axis of the lens. The larger the aperture, or the longer the focus of the lens, the less depth of focus. By inserting a "diaphragm," or "stop"* as it is sometimes called, we are able to reduce the aperture of the lens and increase the depth of focus,

* The stop and diaphragm, although synonymous in optics, are not so, however, in photographic optics, and it is an error to confound the two. A *stop* is placed *in contact* with the lens, and a *diaphragm* some distance from it. The *stop* reduces the lens to its central aperture; the *diaphragm*, on the contrary, allows all the segments of the lens to act, but from different radiating points.

and the smaller the stop the greater the depth. But in doing this we also reduce the amount of light which it transmits, is directly proportioned to the area of the diaphragm aperture. Some idea of the effect of the stop is shown in Fig. 153. Here we have the stop placed close to the lens, which immediately reduces it very considerably. In Figs. 154 and 155 we see the effect of the diaphragm upon the depth of focus of the lens. The rays *r r* coming from a distant point, form, after passing through the lens L, an image at or on the ground glass B. If we move the ground glass to C or to A, the image would immediately spread out and become indistinct. But in the next illustration we see the rays *r r* are caused by the stop to be much less convergent when leaving the lens, and, in consequence, the ground glass could be moved to A or to C without any appreciable alteration taking place in the image.

FIG. 156.—THE IRIS DIAPHRAGM.

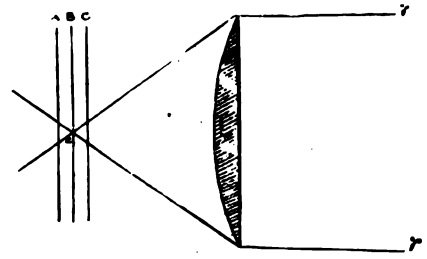


FIG. 154.

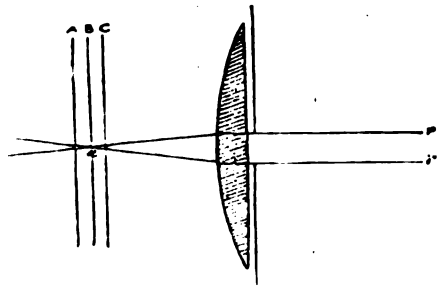


FIG. 155.

FIG. 157.—THE WATERHOUSE DIAPHRAGM.

If we now move the stop to a proper distance from the lens it becomes a diaphragm. In single lenses it is usually placed from one-fourth to one-half of the focal length in front of the lens. In this positin it limits the diameter of the pencils of light, causing them to cross the axis at the aperture of the diaphragm before refraction. In symmetrical doublet lenses the position of the diaphragm should be in the centre of the two combinations. In combinations which are not symmetrical the position is proportionate to the foci of the combinations.

Besides giving greater depth of focus the effect of the stop is also to correct spherical and other aberrations in a lens (see **Aberration.**) The principal points to be remembered in using a diaphragm are these: The larger the aperture the bolder the picture and the more rapid the exposure required. In focusing always remove the diaphragm. The smaller the diaphragm, the longer the exposure, the greater the depth of focus, and the flatter the image.

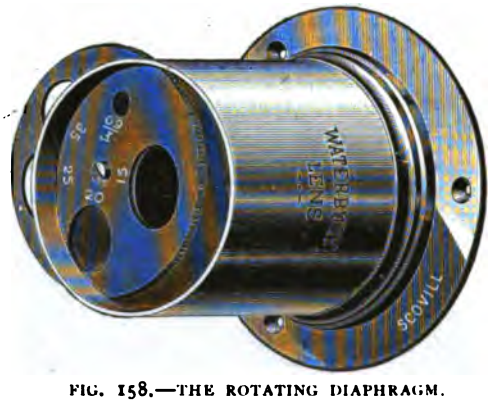


FIG. 158.—THE ROTATING DIAPHRAGM.

Every diaphragm possesses a focal value which is the relation of its diameter to the equivalent focal length of the lens to which it belongs, and it should be numbered accordingly. To find this number first ascertain the equivalent focus of the lens, and then divide this by the diameter of the central aperture of the diaphragm. For example: Focal length of the lens is 6 inches, and the diameter of the diaphragm ½ inch 6 ÷ ½ = 12. The number of the diaphragm is therefore, 12, or, as it is expressed, *f*/12. This system is a very convenient one, as it assists in the calculation of the exposure. If all other conditions be equal the exposures required are proportional to the squares of the denominators of these fractions. The Photographic Society of Great Britain have adopted a different system, taking *f*/4 as the standard, which is termed No. 1. This system is called the Uniform System, and the numbers the U. S. No. By its means the comparative exposures are at once seen. To find out the U. S. No. of any diaphragm marked upon *f*/x system, the following is the rule: Double the focal length of the lens by the diameter of the diaphragm to *f*/x, square the result, and divide by sixteen, which will give the U. S. No. Example: Find the U. S. No. of diaphragm marked *f*/20. 20 × 20 = 400; 400 ÷ 16 = 25, the U. S. No.

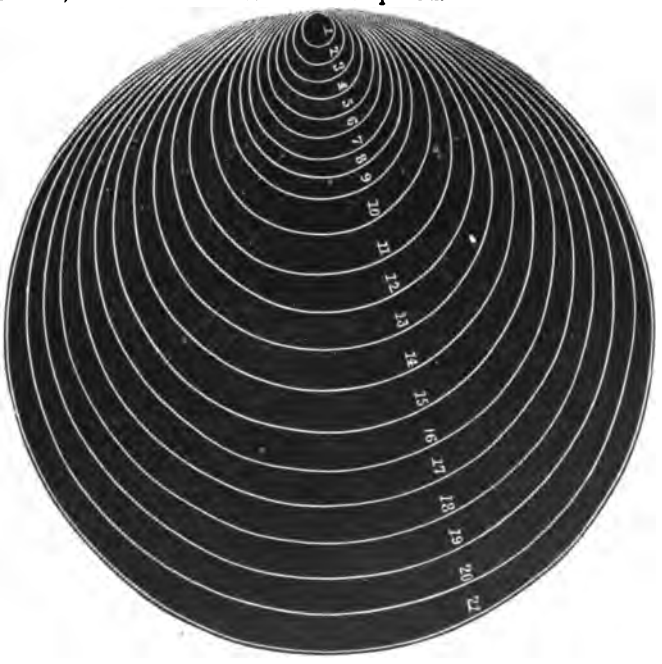
In the following table Mr. S. A. Warburton has calculated the exposure necessary with every stop from *f*/1 to *f*/100 compared with the unit stop of the "uniform system" of the Pho-

tographic Society of Great Britain. The figures which are underlined show in the first column what *f/a* must be in order to increase the exposure in geometrical ratio from *f*/4, the intermediate numbers showing the uniform system number for any other aperture.

f	U. S. No.	*f*	U. S. No.	*f*	U. S. No.	*f*	U. S. No.
1	$\frac{1}{16}$	8½	4.51	36	81.00	69	297.56
1¼	.097	8¾	4.78	37	85.56	70	306.25
1.414	⅛	9	5.06	38	90.25	71	315.06
1½	.140	9¼	5.34	39	95.06	72	324.00
1¾	.191	9½	5.64	40	100.00	73	333 06
2	¼	9¾	5.94	41	105.06	74	342.25
2¼	.316	10	6.25	42	110.25	75	351.56
2½	.390	11	7.56	43	115.56	76	361.00
2.828	½	11.31	8	44	121.00	77	370.56
2¾	.472	12	9.00	45	126.56	78	380.25
3	.562	13	10.56	45.25	128	79	390.06
3¼	.660	14	12.25	46	132.25	80	400.00
3½	.765	15	14.06	47	138.06	81	410.06
3¾	.878	16	16	48	144.00	82	420.25
4	1.00	17	18.06	49	150.06	83	430.56
4¼	1.12	18	20.25	50	156.25	84	440 00
4½	1.26	19	22.56	51	162.56	85	451.56
4¾	1.41	20	25.00	52	169.00	86	462.25
5	1.56	21	27.56	53	175.56	87	473.06
5¼	1.72	22	30.25	54	182.25	88	484.00
5½	1.89	22.62	32	55	189.06	89	495.06
5.656	2	23	33.06	56	196.00	90	506.25
5¾	2.06	24	36.00	57	203.06	90.50	512
6	2.25	25	39.06	58	210.25	91	517.56
6¼	2.44	26	42.25	59	217.56	92	529.00
6½	2.64	27	45.56	60	225.00	93	540.56
6¾	2.84	28	49.00	61	232.56	94	552.25
7	3.06	29	52.56	62	240.25	95	564.06
7¼	3.28	30	56.25	63	248.06	96	576.00
7½	3.51	31	60.06	64	256	97	588.06
7¾	3.75	32	64	65	264.06	98	600.25
8	4	33	68.06	66	272.25	99	612.56
8¼	4.25	34	72.25	67	280.56	100	625.00
		35	76.56	68	289.00		

THE PHOTOGRAPHIC SOCIETY'S (OF GREAT BRITAIN) STANDARD DIAPHRAGMS.

The annexed diagram and table are intended to facilitate the calculation of the proper number with which to mark the diaphragms according to the Photographic Society of Great Britain's Uniform System, already described. This number it is proposed to call the "U. S." (or uniform system number.) The numbered circles in the diagram represent the sizes of stops. The photographer, knowing the equivalent focus of his lens, looks along the line opposite the number which represents the circle nearest inside to his diaphragm, and when he gets to the column headed by that equivalent focus, the number there found is the U. S. number to be marked on the diaphragm. For example: A lens of eight inches equivalent focus has a diaphragm in size about No. 5 on the diaphragm; running the eye along the line opposite No. 5 we find in the column under—"focus eight inches" the No. 11, which is the U. S. number required.



No. of Circle.	4 focus	5 focus	6 focus	7 focus	8 focus	9 focus	10 focus	12 focus	14 focus
1	25	39	56						
2	11	17	25	34	44	56	68		
3	6¼	10	14	19	25	31	40	56	
4	4	6¼	9	12	16	20	25	36	48
5	2⅝	4⅛	6¼	8⅓	11	14	17	25	34
6	2	3⅛	4½	6¼	8	10	13	18	25
7	1⅓	2⅓	3⅓	4⅔	6	8	10	14	19
8	1¼	2	2¾	3⅔	5	6¼	8	11	15
9	1	1⅓	2¼	3	4	5	6¼	9	12¼
10		1	1⅓	2⅓	2¾	3⅓	4⅓	6	8½
11			1¼	1⅓	2	2½	3⅕	5	6
12			⅞	1⅛	1⅓	2	2⅓	3⅓	4⅔
13				1	1¼	1⅗	1⅔	2⅔	4
14					1	1½	1⅓	2¼	3
15						1	1⅛	1⅞	2½
16							1	1½	2
17								1⅛	7⅝
18								1⅛	1½
19								1	1⅛
20									1⅛
21									1

NOTE.—This table, taken from the *American Annual of Photography*, has proved to be very convenient in the calculating of stop values.

Mr. T. R. Dallmeyer has also introduced a system of numbering stops in which the figure obtained by dividing the focal length by the aperture is squared and divided by 10.

It is not absolutely necessary that the aperture on the diaphragm shall be circular. Many other forms haven been devised. Fig. 159 is a diaphragm much used by the writer in hot climates when the distant mountainous background was so actinic that it was almost impossible to obtain correct exposure of background and foreground together. By using a stop of this kind the actinicity of the sky and background was reduced. A similar effect is obtained with Sutton's sky diaphragm (Figs. 160, 161 and 162).

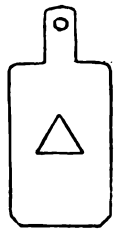


FIG. 159.

The object of this is more clearly shown in Fig. 162. The largest amount of light entering the lens is from the foreground, whilst the sky receives the least.

Fig. 163 is the form of aperture recommended by Fisck for stereoscopic diaphragms.

Within the last few years a new kind of diaphragm, termed the Iris diaphragm, has been devised. It consists of a number of thin pieces of metal fastened to a ring in the lens mount. By turning the ring backwards or forwards the aperture of the diaphragm may be enlarged or diminished at will. A pointer on the outside of the ring indicates the different apertures of the diaphragm. Loose diaphragms are very apt to get mislaid or lost. They should be rivetted together, as shown in Fig. 156. Another form is the rotating diaphragm. In this the apertures are cut upon a circular plate, which is centered, so that its revolution may bring either aperture exactly central with the lens, a small catch indicating to the operator when it is in its proper position. This kind of diaphragm is generally fitted to wide-angle and view lenses.

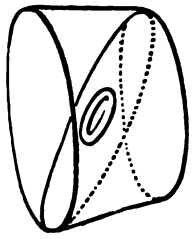
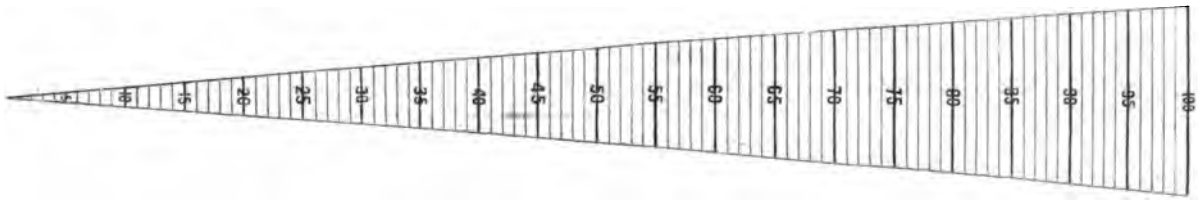


FIG. 160.

SCALE FOR MEASURING DIAMETERS OF STOPS FOR LENSES.



Each cross line varies in length from the adjacent one by $\frac{1}{100}$th of an inch.

To use: Lay the stop flat on this scale, and select the cross line which is of the same length as the greatest diameter of the opening; read this off, by means of the figures, which will be the measurements in $\frac{1}{100}$th of an inch. The equivalent focal length of lens, divided by this measurement of the stop opening, will give the fraction expressing the ratio of aperture to focal length. The rapidity of different lenses, or of the same lens with different stops, is proportional to the squares of these ratios.

DIAPOSITIVE.—A positive made from a negative.

DIATHERMANOUS.—Any substance through which heat can freely permeate is said to be diathermanous or diathermal.

DIAZOTYPE.—See **Primuline Process.**

DICARBONATE.—Carbonate containing one atom of carbonic acid with two of the elements with which it is combined. Synonym, *bicarbonate.*

DICHLORIDE.—A compound of two atoms of chlorine with an element. Synonym, *bichloride.*

DICHROIC.—A substance is said to be dichroic when it assumes two or more colors, according to the direction of the light transmitted to it.

FIG. 161.

DICHROMATE.—A double chromate, as potassium dichromate. Synonym, *bichromate.*

DIFFRACTION.—In optics, the peculiar modification that light undergoes when it passes by the edge of an opaque body by being deflected from its direct course.

DIFFRACTION GRATING.—A number of fine parallel lines placed closely together. When light falls on them it diffracts and produces a spectrum with the rainbow colors.

DIFFUSION.—Literally the act of diffusing or spreading a liquid, &c.

Diffusion of Light.—A ray of light when it does not arrive direct but is spread about, is termed diffused light. The light of the *atelier* is usually diffused with ground glass or translucent material. Diffused light in the camera resulting in fog is that light which does not come direct from the lens on to the plate.

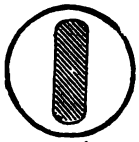


FIG. 163.

Diffusion of Gases.—The passing of one gas into the space occupied by another. The diffusion of gases takes place at a rapidity that is inversely proportional to the square roots of their densities or specific gravities.

Diffusion of Liquids.—If two liquids capable of mixing are placed in contact with each other they will gradually diffuse one into the other.

Diffusion of Focus.—When the focus of the image is spread out it is termed diffused. Dallmeyer constructed a lens in which the back portion of the combination could be moved backwards to diffuse the focus, and give a hazy, soft appearance to the portrait.

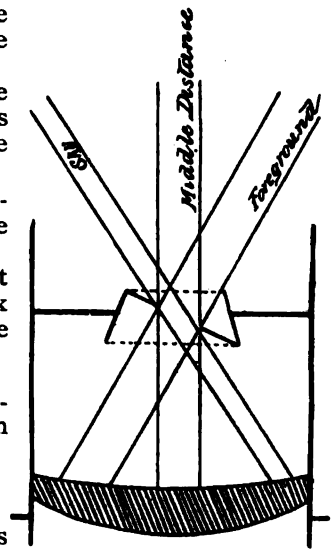


FIG. 162.

DIGESTION.—A process of digestion is used in emulsion-making. The emulsion is exposed to a gentle heat for some time to obtain sensitiveness.

DILUTE.—To make thin with water.

DIMORPHOUS.—Substances which exist in two different forms are termed dimorphous.

DI-NITRO CELLULOSE.—See **Pyroxylin.**

DIOPTRICS.—That branch of science which treats of the different refractions of light on passing through different mediums.

DIORAMA.—A mode of scenic representation in which the spectator and picture are placed in seperate rooms, and the picture viewed through an aperture, the sides of which are continued towards the picture so as to prevent the distraction of the eye by other objects. All light admitted passes through this aperture from the picture, which is illuminated by light from above at such an angle as to be reflected through the aperture towards the spectators. By an arrangement of shutters, screens, reflectors, etc., the light can be modified to represent changes of sunlight, cloud and moonlight, transparent portions of the picture admitting light from behind certain portions which are brilliantly illuminated (Knight). Dioramas were first exhibited in London on September 29, 1823, by M. Daguerre, one of the fathers of photography.

DIOXIDE.—A term applied to an oxide consisting of one atom of a metal combined with two atoms of oxygen.

DIPPER.—The holder for the glass plate when immersing in the nitrate bath used in the wet-collodion process, *q.v.*

These dippers are made of glass, ebonite or of silver wire with hooks at the bottom to hold the plate.

DISH.—The dish, or bath as it is more often called, is a very necessary article in all photographic processes. It is made of various materials—glass, earthenware, celluloid, vulcanite, metals, wood, papier maché, etc. For the principal operations, such as developing, fixing, toning, etc., separate baths should be kept, which should not be used for any other purpose. See also **Bath.**

DISINFECTANT,—A substance which will destroy or neutralise bad odors, and prevent infectious diseases from spreading. Carbolic acid is the most powerful disinfectant known. As a deodorizer, however, carbolic acid is not so energetic as chlorine or permanganate of potash. Sulphuric acid in the liquid state is a powerful disinfectant, as also are mercury salts, such as corrosive sublimate and biniodide; these are much used as antiseptics. A quantity of a disinfectant should occasionally be poured down the dark-room sink and into the various drains about the house.

DISPERSION.—A term used in optics denoting the separation of a ray of homogeneous light by refraction into an infinity of refracted rays of different refrangibility.

Different transparent media have different dispersive powers measured by the length of the spectrum made by them. Flint glass is more dispersive than crown glass, because the spectrum which it furnishes is longer, and it is owing to this difference in dispersive power that we are enabled to eliminate chromatic aberration.

In optical formulæ the measure of the dispersive power of the medium is the fraction—

$$\frac{n_v - n_r}{n_y - 1}$$

n_v being the refractive index for the violet ray, n_r for the red ray, and n_y for the ray of mean refrangibility.

In general, rays of short wave length are more refracted than rays of long wave length, but in some refracting media this law breaks down in part. This is known as *anomalous dispersion.* The term *false* dispersion is applied to the scattering of light by reflection from molecules suspended in transparent media.

DISSOLUTION.—In chemistry, the re-solution of any body into the smallest parts by chemical agency.

DISSOLVING VIEWS.—See **Magic Lantern.**

DISTANCE.—The extreme boundary of view in a picture, that part which appears farthest from the eye. In perspective the *point of distance* is that point of a picture where the visual rays meet. The *middle distance* is the central part of the picture, and the *line of distance* is a straight line drawn from the eye to the principal point on the plane. (See also **Aerial Perspective.**)

DISTILLATION.—The process of applying heat to a liquid, or it may be a solid, in order that certain constituents may pass away in vapor, and by suitable arrangements be obtained in liquid form. When the vapor does not condense as a liquid, but only as fine dust or flour, the process is called sublimation (*q.v.*)

The apparatus for artificial distillation consists of three parts—the still, the condenser, and the receiver. The still is usually made of glass, copper, iron, or earthenware, according to the nature of the substances to be placed in it. In experimental chemical work glass is almost the only material admissible, while in the preparation of alcohol from grain copper stills are commonly employed. The condenser is made in an infinity of forms, the object being to condense the vapors disengaged from the still rapidly and as effectually as possible. For this purpose it is important that the condenser shall expose a larger surface to the cooling medium—water or air. Whatever the form the principle is the same, in that the hot vapors pass through a tube or vessel surrounded with cold water, which, running in a constant stream, passes away more or less warm after it has done its work. The receiver merely consists of a suitable vessel to receive the distillate.

There are various forms of distillation. Those best known are fractional distillation, destructive distillation, and distillation in vacuo.

Fractional Distillation.—A mixture of liquids having different boiling points is placed in a still, and heat is applied. If the temperature be raised slowly, and especially if the vapor requires to rise through a high tube before passing into the condenser, it will be found that the more volatile liquids pass over first in a state of purity and while the others follow as the heat is increased. If the receiver be frequently changed a series of fractions are obtained corresponding to the different substances in the still. For example, if a mixture of glycerine, water, alcohol, chloroform, and ether were distilled, the ether would distil first, then the chloroform, next the alcohol, and lastly the water, while nearly all the glycerine would be left behind. This, then, is fractional distillation.

Destructive Distillation is accomplished by heating non-volatile organic bodies in a retort.

Distillation in Vacuo.—If water is heated in a kettle it eventually boils, and if a thermometer be plunged in it will register 212 deg. Fahr. If the barometer is low, however, the temperature of the boiling water will be somewhat lower than 212 deg. Fahr., and if the barometer is very high the temperature is also high. On the summit of Mont Blanc water boils at 180 deg., while in a vessel from which the air has been removed by an air pump it continues to boil even when the temperature falls down below freezing point. These substances which are injured by heat are distilled in this manner in vacuo.

DISTILLED WATER.—(Formula, H_2O; molecular weight, 18.)—Pure water obtained by distillation. In all delicate and important photographic operations distilled water should be used. Pure distilled water should give no precipitate with $AgNO_3$ showing absence of any chloride; nor with ammonia oxalate, which would otherwise show the presence of lime; nor with barium chloride $BaCl_2$, proving the absence of sulphuric acid. If a drop of permanganate of potassium or Condy's fluid be dropped in the water it should give a pink tint, thus proving the absence of organic matter.

DISTORTION.—When the image formed by a lens upon the focusing glass of the camera

does not coincide with the laws of perspective it is said to be distorted. There are two kinds of distortion—one in which objects are exaggerated in dimensions quite contrary to the laws of perspective. A wide-angle lens is guilty of this distortion, and therefore should never be used unless absolutely necessary to include a view which cannot otherwise be made. The other kind of distortion is produced in most lenses by the refraction of the oblique eccentrical pencils of light by the margin of the lens. Distortion by divergent lenses is just the reverse of that by convergent lenses. Thus the lines Fig. 164 would be distorted as in Fig. 165 with a divergent lens, but with a convergent one they would appear as in Fig. 166.

The position of the diaphragm in a single lens alters the distortion also. If placed in front of the lens the distortion is as in Fig. 165, but if behind the lens it would appear as in Fig. 166.

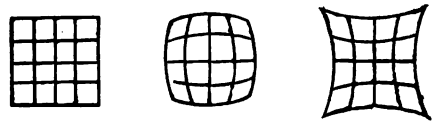


FIG. 164. FIG. 165. FIG. 166.

It is therefore clearly seen that if we use two symmetrical lenses, and place the diaphragm between, the distortion of one is counteracted by the distortion of the other, and the lens is said to be rectilinear. Upon this principle all the non-distorting doublets are manufactured.

The distortion of a single lens is not great unless its focus be very long, and it is only noticeable in taking buildings near to, which should never be done except with a correct lens. Dallmeyer has recently introduced a rectilinear single lens which may be considered a great achievement. See also **Lens.**

DIVERGENT.—A term given to lenses which cause divergence of the rays of light entering them.

DIVERGENT RAYS.—Those rays which, starting from a certain point, diverge or recede from each other in proportion as they recede from the object. The opposite of convergent.

DODGING NEGATIVES.—Comparatively but few negatives are absolutely perfect. The term dodging is used in the printing process to methods of improving the printing qualities of a negative by various dodges. If the negative be very hard and chalky, printing in the sun will sometimes result in a good print; while, on the other hand, if the negative be very weak and flat, it should be printed in the shade, or with a piece of green glass placed over the printing frame. Some negatives are thinner at one end or at one part than another. In such cases the printing frame is placed in a deep box without a lid, with the densest part uppermost, or by sticking pieces of paper over the weaker parts. The high lights of a weak negative can often be improved by touching up with a little yellow dye mixed in varnish.

DOUBLE CONCAVE.—See **Bi-concave.**

DOUBLE CONVEX.—See **Bi-convex.**

DOUBLE DARK SLIDE.—A dark slide capable of holding two plates. (See **Dark Slide.**)

DOUBLE DECOMPOSITION.—The mutual interchange of the atoms of two compounds. With solutions this is often attended by precipitation. Thus, if a solution of silver nitrate $AgNO_3$, and another of salt NaCl, be added together, the following change takes place—$AgNO_3 + NaCl = NaNO_3 + AgCl$, the silver chloride being precipitated. In the silvering of albumenized paper the same effect takes place, the silver chloride precipitate being held on the paper.

DOUBLE EXPOSURE.—An error often made by amateurs in unconsciously exposing the same plate on two occasions. To obviate this, each dark slide should be numbered and fitted with a little tablet, upon which the subject of the exposure may be written. Many devices have recently been made to prevent double exposure. They mostly consist in self-acting locks or catches on the dark slide, which cannot be opened a second time without the knowledge of the operator.

DOUBLE EXTENSION.—An arrangement in a camera by which the base-board, to which the front and back of the camera are attached, being made double, is extended nearly double its usual length, one portion falling upon or into and sliding over the other. The object of this is to allow of long focus lenses being used.

DOUBLE EXTENSION CAMERA.—See **Camera.**

DOUBLE IMAGE.—A double or blurred image is sometimes obtained in the camera, caused by movement during exposure on a windy day. The camera should be steadied with a heavy weight attached to it. The camera should fit firmly on to the stand, and be free from vibration, otherwise double images will be the result. Double images are also sometimes caused by rapid shutters having a double movement; the shutter flying up hits the top and shifts the position of the camera.

DOUBLE PRINTING.—A method of printing from two negatives, or the combination of portions of two negatives.

DOUBLE REFRACTION.—See **Refraction.**

DOUBLET LENS.—See **Lens.**

DOUBLE TRANSFER PAPER.—A paper used in the double transfer process. (See **Carbon Process.**)

DOUBLE TRANSFER PROCESS.—See **Carbon Process.**

DRACHM or **DRAM.**—A small weight. In *apothecaries' weight*, the eighth part of an ounce, or 16 grains. In *avoirdupois weight*, the sixteenth part of an ounce.

DRAGON'S BLOOD.—A resin, so called on account of its red color. It is very opaque and brittle, and is tasteless and without odor. Pure dragon's blood dissolves with a fine red color in alcohol or ether, and also in both fixed and volatile oils. It is largely used in the preparation of varnishes.

DRAINAGE.—The condition of the drains is, to the photographer, a most important consideration. In operating with photographic chemicals, sinks should be provided with a large sized waste pipe, down which quantities of water should be made to flow at convenient periods. Very often several different chemicals are thrown down the drainpipes which mix together, forming bad and noxious gases. Acids should never be emptied down the sinkpipes, as they will quickly eat their way through the metal tubing. Large quantities of disinfectants should be used, especially in the warm weather.

DRAINING RACK,—Racks made of wood, metal or porcelain for draining or drying plates.

DRAWING PAPER, PRINTING ON.—Very good effects may be produced by printing with silver chloride on a rough drawing paper such as Whatman's. The picture should not be mounted, but printed like engravings with very wide margins. The roughness of the drawing paper gives that artistic dull appearance of the engraving. The method of preparing the paper is as follows: The drawing paper is cut into convenient sizes and floated on a shallow dish containing—

Gelatine	25 grains
Water	6 ounces
Salt (pure)	25 grains

One minute will suffice, when it is removed and hung up to dry. When dry a slight pencil mark is made on the salted side for future guidance. The paper may be sensitized by floating on the silver bath used for albumenized paper, or the silver solution can be applied with a broad camel-hair or bristle (*q.v.*). The strength of the solution should be about 60 grains of silver nitrate to the ounce. When sensitized the paper is attached to clips and hung up to dry in a yellow light. When dry the usual printing operations are performed. A piece of black paper is cut the size of the sensitized paper, and a hole cut in the centre the size and shape of the picture. This is used as a mask in printing, and gives the wide margin. Printing is carried out to a deeper extent than with albumen paper, as there is always an unavoidable loss of brilliancy in the toning and fixing operations. The following toning bath answers well:

Gold bichloride	1 grain
Sodium bicarbonate	40 grains
Distilled water	10 ounces

This gives the black engraving tone so much admired. After toning fix with ordinary ten per cent. hyposulphite bath and well washed.

DRAWINGS.—Chalk and pencil drawings may be fixed so as not to suffer from slight abrasion by washing them with skimmed milk, or with water holding in solution a little isinglass or gum. If milk be used, great care must be taken to thoroughly deprive it of the whole of the cream, or it will cause the drawing to look streaky. An easy way is to float the drawing on the surface of the liquid placed in a shallow dish, after which it is placed in an inclined position upon white blotting paper to dry.

In photographing drawings the paper or board upon which they are drawn is sometimes yellowed by age. This gives with the ordinary photographic process a dull, dirty appearance. It is very necessary in these cases to make use of the isochromatic process (*q.v.*)

DROPPING BOTTLE.—A small bottle for supplying liquids in small quantities or in drops. See Fig. 167.

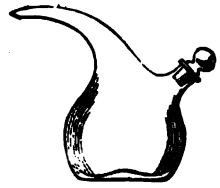


FIG. 167.—DROPPING BOTTLE.

DROPPING TUBE.—A tube open at both ends, the lower aperture being quite small. The tube is charged with the liquid, and the finger closed upon the upper end, and when relaxed it allows the liquid to exude in drops from the lower end. The dropping bottle, (Fig. 167,) pipette burette, and drop meter have all a similar purpose.

DROP SHUTTER.—See **Shutters.**

DRYING BOX,—A light tight box used for the drying of plates and other preparations. The arrangements necessary to constitute a good drying box, or cupboard, are first a contrivance by which a current of air is made to pass through it and take up all the moisture. In order to do this the air passing through should be slightly warmed, so that it will take up more moisture. Fig. 168 shows the principle upon which the shelves to hold the plates should be fitted, so as to allow a free current of air to pass through. The temperature of the drying box should, of course, be raised, but without ventilation this would be useless, as water may be saturated with moisture at any temperature below that of boiling point, but the moist air must be removed to allow the dry air to come and carry away the moisture.

A good form of drying cupboard for gelatine plates is given under **Dry Plates.**

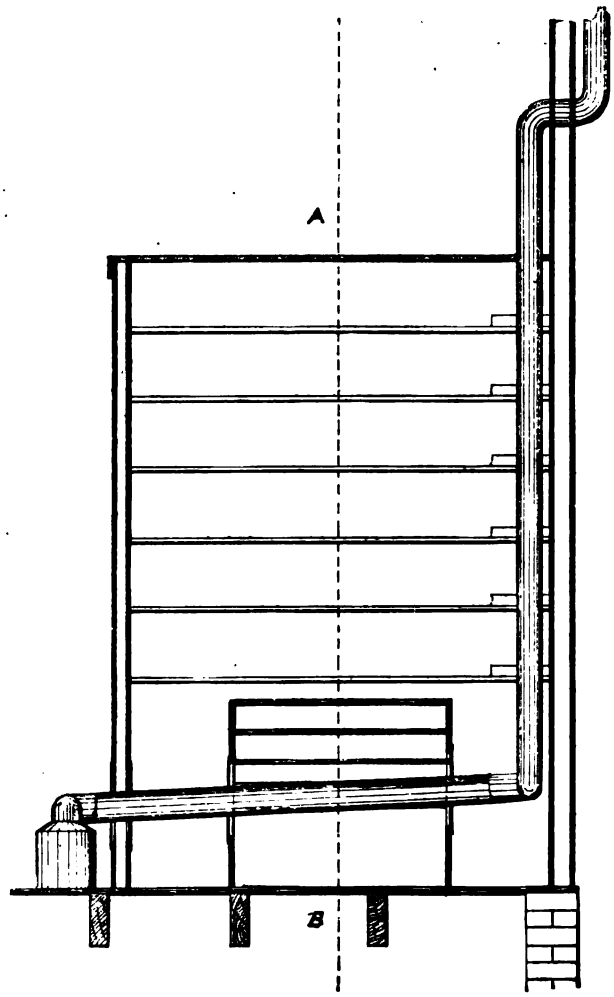


FIG. 168.—DRYING BOX.

DRYING OILS.—Linseed and other oils, if heated with lead oxide, absorb oxygen from the air, and become dry. They are used as a base to many paints and varnishes, assisting in the drying operation.

DRY COLLODION PROCESS.—See **Collodion Emulsion Process.**

DRY DISTILLATION.—See **Destructive Distillation.**

DRY-PLATES.—Plates of glass of different sizes, coated with a film of gelatine in which a sensitive silver salt is emulsified. Dry plates are now manufactured in such large quantities that it is rarely beneficial to either amateur or professional photographer to manufacture his own, unless for special purposes. The competition in price of commercial dry plates has resulted in the manufacture of many kinds which are weak in emulsion and silver. These should be avoided, as the slight difference in price is by no means economical.

Under the heading **Emulsion** will be found the necessary instructions for making the bromide of silver, or other gelatine emulsion ready for coating the glass plates. We shall first describe the method of preparing dry plates by hand, and afterward by machinery.

The emulsion ready filtered is placed in a convenient flask for pouring. Some glass plates of the required size are then thoroughly cleaned by immersion in nitric acid, and then rubbed with caustic soda and a little alcohol, and set up on end on blotting paper to dry.

With some kinds of emulsion it is necessary, to prevent frilling, to first coat the plates with a substratum, which may be made up from either of the two following formulæ. The first is Mr. Forrest's and the second Dr. Vogel's.

White of egg	1 ounce
Water	20 ounces
Methylated spirit	1 ounce
Carbolic acid	20 drops

The carbolic acid is added to the spirit, stirring the mixture the while, when it is poured into the albumen and water previously mixed together.

SOLUTION NO. 1.

Gelatine	50 grains
Acetic acid	½ ounce

Place these in a bottle, and warm till a solution takes place.

SOLUTION NO. 2.

Chrome alum	10 grains
Water	1 ounce

Take 2½ parts of No. 1, one part of No. 2, and add them to 70 parts of methylated spirit. Filter and coat the plates, then clean and dry as with collodion.

The next point to be considered is the leveling stand, or shelf, upon which the plates are to rest after coating. An ordinary triangular leveling stand will answer the purpose. The following contrivance is, however, simpler (see Fig. 169). A piece of thick plate glass about three feet long and two feet broad is laid upon the table, and three mahogany wedges placed under it in the position shown. A small spirit level D is placed across the plate as shown, and the two wedges C and B are altered until the bubble in the level is in the centre. It is then turned lengthways across the plate, and the bubble again adjusted to the centre by altering the position of wedge A, not disturbing the other two in the least. The plate should now be perfectly level.

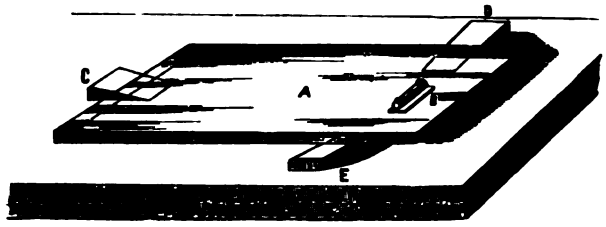


FIG. 169.—LEVELLED GLASS PLATE.

The emulsion should be kept at a temperature of about 90 deg. Fahr. by a hot water bath. The plate is laid hold of by a pneumatic holder, or by the tips of the fingers, and the necessary quantity of the emulsion poured on. For a whole plate 8½ by 6½ inches about three drachms are required, and other sizes in proportion. This is poured on as shown in Fig. 171, care being taken that no air-bubbles are formed. Arrangements are now made for pouring emulsion on to plates. They are somewhat in the shape of teapots, with an inner vessel into which the emulsion is poured. The emulsion that is poured out comes from the bottom of the bulk, so that bubbles on the surface are avoided.

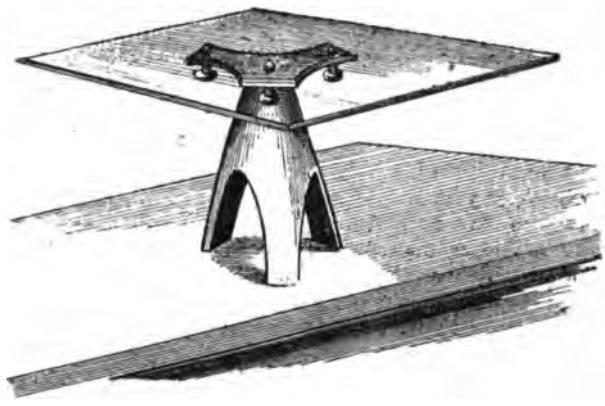


FIG. 170.—LEVELLING TABLE.

When the emulsion is poured on to the plate the latter is slightly tilted, and the emulsion made to run into the right-hand top corner, and from there to the left-hand top corner, left-hand bottom corner, and finally to the right-hand bottom corner. To facilitate the coating a larger amount than required may be poured on, and after flowing over the plate a portion may be returned to the bottle, leaving only the required quantity on the plate.

The temperature of the room should be between 55 degrees and 65 degrees Fahrenheit.

The plate after coating is slowly rocked about until the emulsion is evenly spread, when it is placed upon the leveling stand, on a level tank filled with ice water to cool the emulsion and to cause it to set as rapidly as possible. Another plate is then coated in the same manner, and if the leveled glass plate be full, those that have set may be removed to the drying box or cupboard.

Another method of coating is the following, usually adopted by the writer. The glass plate is placed upon a leveling stand, and arranged perfectly level. The exact quantity of the emulsion is then poured on to the centre of it, and with a spreader made of a piece of bent glass rod or tubing, the emulsion is spread evenly over the plate.

Plates may also be coated by brushing a small quantity of the emulsion over with a wide badger hairbrush, and afterwards pouring on the necessary quantity

For commercial purposes the process of preparing dry plates by hand would be too expensive. Machines have, therefore, been constructed, by means of which several thousands can be

coated per diem. The principles of the Edwards' machine are these: In a trough containing the emulsion a roller of silver or glass rapidly revolves. Upon one side of the roller is a metal plate, which rests upon it and scrapes off the thin film of emulsion that the roller takes up in revolving, the thickness of the film being regulated by the speed of the roller. This thin layer of emulsion scraped off runs down on to the glass plates, passing one after another beneath, giving a perfectly even coating. The coated plates then run through a part of the machine, which is kept very cool, and they are very soon set. An operator at the other end then removes them one by one as they come out, and places them in a rack, which, when full, is sent up to the drying room. Another machine for coating plates is that of Mons. Hutinet. It has the appearance of a long, skeleton table, about sixty or seventy feet long. Along this table endless bands of a stout material are constantly traveling, kept in motion by a small gas or hot-air engine. At one end of the table is the arrangement for coating. A small hot-water cistern, containing the

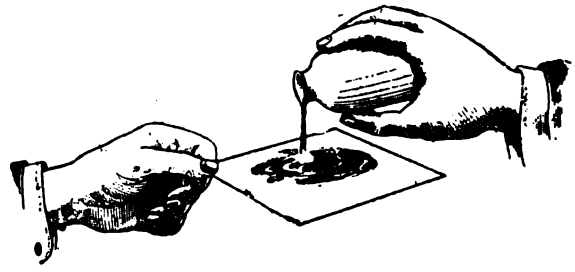


FIG. 171.—COATING THE PLATE.

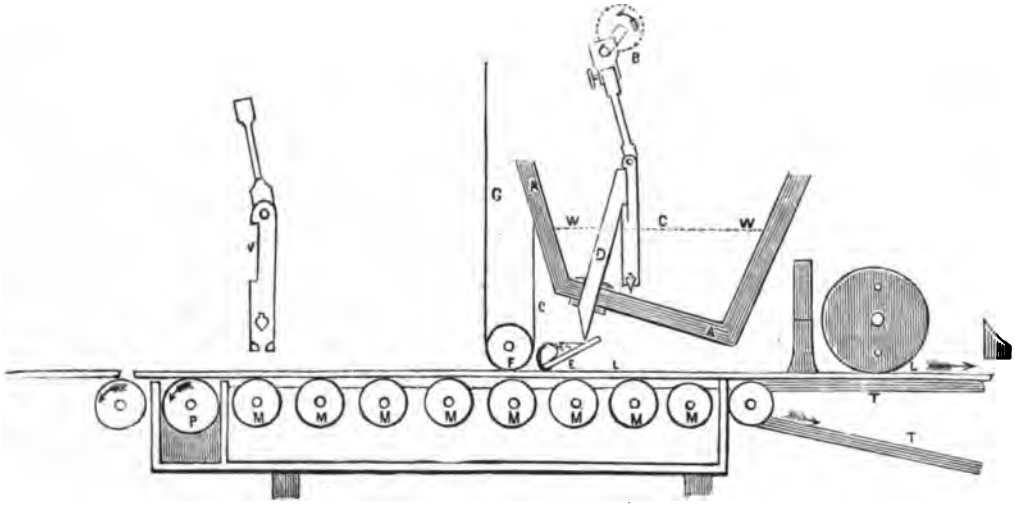


FIG. 172.—CADETT'S PLATE COATING MACHINE.

jar with the prepared emulsion, is placed on a raised platform. A small pipe fitted with a glass stop-cock conveys the emulsion from the cistern in an even stream to an open glass cylinder. This cylinder is perforated on its lower part with a number of holes, through which the emulsion oozes, and spreads itself over an india-rubber roller below. Underneath this roller the glass plates are made to pass along by the endless band, and as it presses lightly upon them it applies the emulsion in a thin even layer. The plates, after they have received the necessary coating, pass along the lengthy machine, kept quite level, so that they are quite set before they reach the other end, from whence they are conveyed to the drying room.

The drying of gelatine plates is by no means an easy matter. The principal desideratum is a current of dry air, which carries with it the moisture from the gelatine, and escapes with it out of the drying chamber or cupboard. In Fig. 168 we have a good form of drying box. The direction of the arrows shows the passage of current of air. In the pipe which conveys the vitiated air out of the room is a gas flame, which can be regulated through the door. The heated air from this flame will rapidly ascend, drawing with it the air from the drying box in which the plates are placed. Some small holes are made to allow of the entrance of the fresh air.

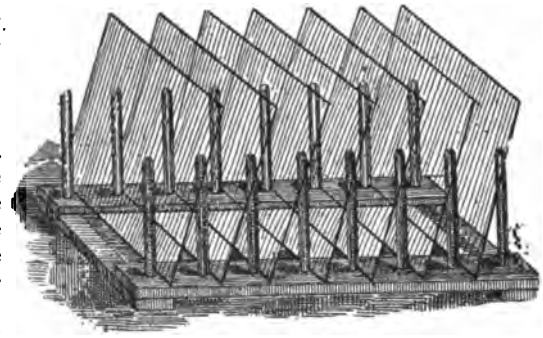


FIG. 173.—DRYING RACK.

Great care should be taken to prevent dust from reaching the plates during the drying operation, also that the temperature of the room or cupboard be kept even. About 80 degs. Fahr. is about correct. Sudden changes of temperature will produce markings upon the surface of the

plates. The door of the drying cupboard should never be opened after the plates are put in until they have been allowed ample time to dry.

The drying operation should take from six to eight hours. It should not be hastened, as quick drying is a great mistake, and often results in bad plates and frilling.

Plates may be dried in an hour, if urgently required, by placing each plate when thoroughly set into a dish of methylated spirit, quite free from resinous matter, for about ten minutes. When taken out it will dry in less than an hour.

With all these operations the most careful precautions must be taken to exclude all light, especially if the emulsion be very highly sensitive. In coating the plates the light used should be only sufficient to enable one to work carefully. All parts of the room should be carefully looked to. Fig. 174 shows a plan of a light-tight door, upon which principle it would be well to construct the door of the room or of the drying box.

If the plates have been made in large sizes, it will be necessary to cut them to the various smaller dimensions required. Some workers cut the plate on the film side, while others prefer to cut from the back. The better plan is to first cut the gelatine film with a sharp knife, and afterwards turn the plate over and divide the glass with a good glazier's diamoud. Every precaution should be taken to avoid detaching the film from the glass, and to prevent the fine glass powder or chips produced in cutting from getting on to the surface of the film and producing pinholes.

Before packing the plates they are carefuly examined and those which have markings, air bubbles, or other defects are put aside.

Air bubbles are usually caused in the pouring out of the emulsion. The vessel containing the emulsion should be held as near to the plate as possible.

Frilling of the film is sometimes due to unequal drying. If plates be dried in a box that is imperfectly ventilated, the outside parts become dry, leaving a patch of undried emulsion in the center. At the junction of the two parts frilling may be looked for. In warm weather plates are more likely to frill than in cold, as the emulsion remains upon the plate in a liquid state for a longer time, allowing the silver salts held in suspension in the emulsion to fall down and settle on the glass, thus diminishing the adhesive surface. Plates that frill easily may be used with safety if coated with a plain collodion made up with—

Pyroxyline (tough)	6 grains
Alcohol (.820)	½ ounce
Ether (.725)	½ ounce

immediately preceding development, the solvents being washed away in a dish of clean water, and the developer applied; or the plates may be coated with the collodion and allowed to dry if they be immersed in one part of ether and three parts of alcohol previous to development.

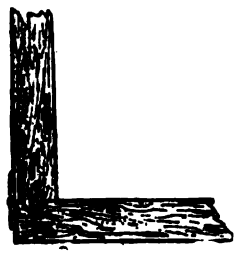


FIG. 174.

Opaque spots found on the film are generally due to dust settling on the film in drying.

Comet-like and other peculiar markings are due to irregular drying. Precautions should be taken that a perfectly even current of air passes through the drying box.

There are several methods of packing gelatine dry plates. The most simple way is to place them face to face with little frames, made the same size as the plate, of strips of cardboard about $\frac{3}{16}$ in. wide. All the different methods have really the same end, *i. e.*, to keep the sensitive films from touching each other. For those who do not manufacture large quantities light-tight boxes with grooves to hold the plates will serve every purpose.

DUST.—Present in the atmosphere from various causes. Its existence is most easily seen when a beam of light traverses the air, lighting up the suspended molecules. Aiken has devised an apparatus for counting the number of dust particles in a given sample of air or gas.

Dust is a great nuisance to the photographer, producing black or white specks in the positive or negative. Before a dry plate is laid in the dark slide it should be dusted with a camel-hair brush, or if any dust be adhering to it during exposure it will show in the negatives as tiny white spots and in the positive as black ones. The negative should also be dusted before placing it in the printing-frame, or the same result will occur, except that this time we obtain little white spots in the positive. In the manufacture of photographic plates and paper the utmost precautions must be taken to prevent dust settling on and adhering to the wet films.

DUSTING-ON PROCESS.—See **Powder Process.**

DUTCH VARNISH.—See **Varnish.**

DYED SCREEN.—A colored screen used in the orthochromatic process, *q. v.*

DYE PROCESS.—See **Primuline Process.**

DYES.—A large quantity of coal tar and other dyes are used in photography, in the ortho-

chromatic or isochromatic process, as sensitizers to the yellow and orange rays. The principal of these are coralline, aldehyde green, chinolin, eosin, erythrosin, and cyanin. (See **Orthochromatic Photography.**)

The use of the dye as a sensitizer is more clearly explained under **Orthochromatic** process. It might be as well here to mention, however, that errors have often been made by writers in stating that red dyes render the plate sensitive to red rays, green dyes to green rays, and so on. Many dyes act quite to the contrary. Fuchsine or magdala red cause bromide of silver to be sensitive to yellowish green and not to red, while aldehyde green sensitizes for red rays. The general rule is that dyes make bromide of silver sensitive to those rays which they absorb, although all dyes do not act in this manner. Those dyes which bleach rapidly in the light are usually the best, although there are many exceptions to this rule. Triphenylic red, fuchsine, eosine, cyanine, picrate of methyl, magdala green, carmine, annatto, turmeric, chlorophyl, methyl violet, alkaline blue, rosaniline and aldehyde green have very peculiar effects. If these dyes be mixed with bromide or chloride of silver, and exposed to light, the bromide or chloride of silver shows an increased sensitiveness to those parts where the absorption spectra of the respective dyes lie; the action being only visible if certain substances which serve as sensitizers are present, such as silver nitrate, tannin, pyrogallic acid, etc.*

DYE SENSITIZERS.—Dyes used as sensitizers in the orthochromatic process, *q. v.*

DYNACTINOMETER.—An instrument for measuring the intensity of actinic power, or for comparing the rapidity of lenses.

EAU DE JAVELLE.—A solution of chloride of potash, sometimes used for eliminating the hyposulphite of soda from the films of the negative, or from the prints after fixing. It is also used for the reduction of too intense negatives, its reducing action being due to the free chlorine evolved. It may be prepared as follows:—

Dry chloride of lime	2 ounces
Potassium carbonate	4 ounces
Water	40 ounces

Mix the chloride of lime with 30 ounces of the water, and dissolve the potassium carbonate with the remainder. Then mix, boil, and filter, and it is ready for use.

EBONITE.—A black ebony-like substance prepared with sulphur and caoutchouc. The proportion of sulphur is from forty to sixty per cent., and to this may be added shellac, gutta-percha, zinc sulphates, antimony or copper. It is used for making photographic dishes, and for dippers in the collodion process.

EBULLISCOPE.—An instrument for determining the strength of a liquid by ascertaining its boiling point.

EBULLITION.—The act of boiling, the condition into which a liquid is thrown by the application of heat, which causes an agitation, or bubbling, arising from the escape of portions of the liquid in an aeriform state. If the bottom of an open vessel containing water be exposed to heat, the lowest stratum of fluid will expand, becoming specifically lighter, and rising through the colder or heavier particles. In this manner the heat is diffused through the whole mass of liquid by a translation of the several particles from the bottom to the top, and the top to the bottom, in rapid succession.

The temperature at which liquid boils in the open air varies with the degree of atmospheric pressure—as we ascend from the sea level the boiling point becomes lower. At St. Gothard, at an altitude of 7,000 feet, the boiling point of water is 199.22, while at Farm of Antesana, 13,000 feet high, the boiling point is only 187.34. The following numbers, taken from Regnault's tables, show how the boiling point is affected by pressure:—

TEMPERATURE CENTIGRADE.

0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 96°, 109°.

PRESSURES IN ATMOSPHERE.

0.006, 0.012, 0.023, 0.042, 0.072, 0.121, 0.196, 0.306, 0.466, 0.691, 1.000.

If, therefore, the pressure be 0.023 atmosphere, water will boil at 20° C, or 68° Fahrenheit. In *vacuo* all liquids boil at a temperature of about 124° Fahr. lower than under the average atmospheric pressure. The following is a table of the boiling points of the most important fluids:

	Fahr.
Ether	96°
Ether sp. gr. 0.736	100°
Alcohol sp. gr. 0.812	173.5°
Nitric acid 1.500	210°
Water	212°
Ammonia	140°
Sulphuric acid sp. gr. 1,848	600°
Linseed oil	640°
Mercury	662°.

* Vogel in "Photographische Mittheilungen."

EDGING.—In the collodion dry-plate process the plate is sometimes edged with albumen, gelatine or indiarubber, to cause adhesion to the film during development. The usual practice is, however, to coat the whole of the plate with a substratum.

EFFLORESCENCE.—A term applied in chemistry to the formation of loose fine crystals on the surface of a porous substance by gradual decomposition on exposure to the air.

EFFLUVIOGRAPHY.—A term applied by Tomassi to the action which the silent discharge has upon a sensitized gelatino-bromide plate. An image is obtained in complete darkness after a few minutes' exposure, and may be developed in the usual manner, the silent discharge producing the same effects as the ultra violet rays, and forms, possibly, a connecting link between the two extreme rays of the spectrum of what may be termed electric rays.

EGG ALBUMEN.—The albumen contained in the eggs of birds and largely used for the manufacture of albumen paper. See Albumen.

EGG, WHITE OF.—Is used as a glaze or varnish. Separate the white from the yolks, whisk into a froth, and let it stand for about 24 hours, then strain through muslin.

ELASTICITY.—That property of matter which enables a body whose form or bulk has been changed by force to support without disintegration or further yielding to the continued action of that force, and to recover its original form when left to itself. With gases and liquids the only kind of elasticity that can exist is elasticity of bulk, but no portion of a fluid can sustain the action of a deforming force.

ELECTRIC LIGHT.—The electric light is now used in many large photographic works, and in a few studios for portraiture. For enlarging and printing it is now much used. The heavy outlay in an electric installation is, however, the chief drawback to its more universal use.

For portraiture at night the electric light is generally used, the light being fitted in the focus of a parabolic reflector, so that it will be reflected in parallel rays.

ELEMENT.—An element is a substance that has hitherto resisted all efforts to divide it into simpler forms of matter, and it is therefore supposed to consist of one kind of matter only. The following is a list of the various elements at present known, with their symbol and atomic weight. Those marked with an asterisk are non-metallic elements, the remainder being metals, although the distinction is in reality not clearly defined, as one or two—arsenic and antimony, for instance—are on the border line.

TABLE OF ELEMENTS.

Name.	Symbol.	New Atomic Weight.
Aluminium	Al	27
Antimony (*Stibium*)	Sb	120
Arsenic	As	75
Barium	Ba	137
Beryllium	Be	9
Bismuth	Bi	208
Boron*	B	11
Bromine*	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon*	C	12
Cerium	Ce	140
Chlorine*	Cl	35.4
Chromium	Cr	52
Cobalt	Co	58.6
Copper (*Cuprum*)	Cu	63
Didymium	Di	142
Erbium	E	166
Fluorine*	F	19
Gallium	Ga	70
Germanium	Ge	72.3
Gold (*Aurum*)	Au	196.5
Hydrogen*	H	1
Indium	In	113 4
Iodine*	I	126.5
Iridium	Ir	192.5
Iron (*Ferrum*)	Fe	56
Lanthanum	La	138
Lead (*Plumbum*)	Pb	206.4
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	55
Mercury(*Hydrargyrum*)	Hg	200

TABLE OF ELEMENTS.

Name.	Symbol.	New Atomic Weight.
Molybdenum	Mo	96
Nickel	Ni	58.6
Niobium	Nb	94
Nitrogen*	N	14
Osmium	Os	195
Oxygen*	O	16
Palladium	Pd	106
Phosphorus	P	31
Platinum	Pt	194.4
Potassium (*Kalium*)	K	39
Rhodium	Rh	104
Rubidium	Rb	85
Ruthenium	Ru	103.5
Samarium	Sa	150
Scandium	Sc	44
Selenium*	Se	79
Silicon*	Si	28
Silver (*Argentum*)	Ag	108
Sodium (*Natrium*)	Na	23
Strontium	Sr	87.5
Sulphur*	S	32
Tantalum	Ta	182
Tellurium*	Te	125
Thallium	Tl	204
Thorium	Th	232
Tin (*Stannum*)	Sn	118
Titanium	Ti	48
Tungsten (*Wolfram*)	W	183.6
Uranium	U	240
Vanadium	V	51
Ytterbium	Yb	173
Yttrium	Y	89
Zinc	Zn	65
Zirconium	Zr	90

Besides these there are one or two other doubtful elements, such as davyium, decepium, mosandeum, nephmium, etc., which cannot be entered in the above list, as their existence is doubted by many chemists, and the atomic weight unknown.

In the third column we have the atomic weight; hydrogen being the lightest element known, is taken as unity. See also **Chemistry.**

ELEMI.—The resinous product of various terebinthinous trees used for making varnishes. There are many varieties. The principal are obtained from the *Balsamodendron ceylonicum* of the West Indies, and the *Icica icicariba* of the Brazils. A Mexican elemi is obtained from the *Elaphrium elemiferum.* It is a brown-yellowish translucent resin, having a peculiar odor resembling fennel. If added to varnishes it prevents their cracking as they dry. If distilled with water it yields a transparent colorless oil, which boils at 166°C.

ELIMINATOR, HYPO.—Any solution used for the purpose of eliminating all traces of sodium hyposulphite from dry plates or paper pictures after fixing. Hypochlorite of zinc, eau de javelle, alum, lead acetate, peroxide of hydrogen, and many other substances will effect this.

Abney recommends the employment of a saturated solution of alum as the best hypo eliminator. The following will also serve the purpose:

Barium dioxide	1 ounce
Glacial acetic acid	1 ounce
Water	4 ounces

The barium dioxide is first reduced to a fine powder, and then added gradually to the water and acid, shaking till dissolved. A few minutes' immersion in this solution will remove all hyposulphite.

ELLIOTYPE.—An unused process, patented some years ago, for enabling artists to obtain an indefinite number of copies of their works. A painting is made upon glass in body color, more or less transparent according to its density and the thickness with which it is applied, the painting being then treated as a negative, and positives printed in the usual manner.

ELUVIATION.—A term applied to the process of separating, by means of water, the finer particles of a powder from the heavier ones. A stream of water is flowed in a vessel containing the substance, carrying with it the fine powder, which is conveyed to settling vats, where it settles at the bottom, and the water is run off.

EMBOLITE.—A chloro-bromide of silver in the form of an isometric mineral of a green or dark color, and found in Chili and Mexico. Its composition is said to be silver 61.1 to 71.9, bromine 7.2 to 33.8 chlorine 5.0 to 20.1.

EMERY.—A dark colored, exceedingly hard mineral. It is reduced to powder, and used for grinding and polishing metal, glass, etc.

EMPYREUMA.—The burnt smell and acid taste which results when vegetable or animal substances are decomposed by strong heat.

EMULSIFY.—To make or form as emulsion.

EMULSION.—In photography this term is usually applied to a mechanical mixture of a sensitive salt of silver in extremely minute division, the particles being held in suspension in some viscous substance, such as gelatine, collodion or albumen, and usually having the appearance of thick milk. To more clearly explain the foregoing, if in a vessel containing water, we pour a small quantity of a solution of common salt, and afterward pour in a little nitrate of silver solution, a white substance (silver chloride) is instantly formed, which would soon fall to the bottom, and the clear water could be decanted off. But if instead of water we take a warm solution of gelatine, and place both salt and silver solutions into it, the same formation instantly takes place, with this difference, it does not sink to the bottom of the vessel, owing to the viscous nature of the gelatine, which holds it up and allows it to be spread evenly over plates and paper.

There are a great variety of emulsions for different purposes, the chief being the bromide or bromo-iodide for plates and bromide paper, and the chloride emulsion for lantern plates, transparencies for development, or for printing out.

In the manufacture of bromide emulsions a knowledge of chemical combination and equivalents is almost essential, as a definite quantity of the bromide, iodide or chloride must be taken to unite with the silver. If too little be taken we get an excess of free silver which would be ruinous. With a view to the simplification of the calculations necessary in emulsion-making, Mr. William Ackland* has worked out the following useful tables by which any person can calculate the proper quantity of silver or of haloid salts in any formula. In this table the principle bromides, chlorides, and iodides likely to be used in emulsions of either gelatine or collodion have been included. Table I, gives the actual weight of haloid or silver required to convert or combine with one grain of the other, so reducing the operation to one of simple multiplication or division.

TABLE I.

	Equivalents.	Weight of $AgNO_3$ required to convert one grain of silver haloid.	Weight of soluble haloid required to convert one grain of $AgNO_3$.	Weight of silver haloid produced by one grain of *soluble* haloid.	Weight of soluble haloid required to produce one grain of silver haloid.	Weight of silver haloid produced from one grain of $AgNO_3$
Ammonium bromide	98	1.734	.576	1.918	.521	
Potassium "	119.1	1.427	.700	1.578	.633	
Sodium "	103	1.620	.606	1 825	.548	1.106
Cadmium " (coml.)	344†	.988	1.012	1.093	.915	
" " (anh.)	272†	1.25	.800	1.382	.723	
Zinc "	225.2†	1.509	.663	1.670	.600	
Ammonium chloride	53.5	3.177	.315	2.682	.373	.844
Sodium "	58.5	2.906	.344	2.453	.408	
Ammonium iodide	143	1.172	.853	1.620	.617	
Potassium "	166.1	1.023	.977	1.415	.707	1.382
Sodium "	150	1.133	.882	1.566	.638	
Cadmium "	366†	.929	1.076	4.284	.778	

* *British Journal*, September 20, 1880.

† These salts combine with two equivalents of silver nitrate, so that practically the real equivalent is one-half that given.

The manner in which this table is used is this. Supposing we wish to make an emulsion, say, about ten ounces of a new formula, which is written down, say, as follows:

Potassium bromide	150 grains
Potassium iodide	10 grains
Ammonium chloride	10 grains
Gelatine	200 grains

We require to know how much silver nitrate should be used for sensitizing the mixture. We take the first column, in which is given against each haloid the exact quantity of silver nitrate required to fully decompose one grain. Taking, then, the salts in the above formula, and multiplying the figures found in the first column by the number of grains of each used, we get the following:

Potassium bromide	150 × .427 = 214	Weight of silver nitrate required.
Potassium iodide	10 × 1.023 = 10.23	
Ammonium chloride	10 × 3.177 = 31.17	

Total quantity of silver nitrate required for conversion, 256.00 grains. Two hundred and fifty-six grains of silver nitrate would thus make an emulsion in which the salts were equally balanced, but, as it is desirable that the haloids should be in excess, we might write down 250 grains as the amount of silver to be used.

Some operators prefer to calculate from the quantity of silver contained or used in the emulsion, that is to say, they fix the quantity of silver to be used, and then find out how much salt is required to convert it. Here we use the second column in the same manner. Thus, if we decide on using in ten ounces of emulsion two hundred grains of silver nitrate, and to employ ammonium bromide as the haloid, the .576 × 200 = 115.2 grains of ammonium bromide will be required, or practically 120 grains, to allow for an excess.

Columns III. and IV. will be found useful for calculating and working out the best proportions for emulsions containing a mixture of different haloids, as the effect depends upon the proportions in which the bromide, iodide and chloride of silver are present. These columns show the relation which exists between the quantity of soluble haloid employed and the actual weight of silver salt formed. Supposing for instance, we desire to make bromo-iodide emulsion in which the proportions of silver iodide to bromide are to be as 1 to 15, and the quantity of emulsion, we will say, five ounces. In that bulk of emulsion a suitable and convenient proportion of silver bromide would be 105 grains. The iodide would, therefore, be seven grains. If ammonium salts be employed we have the figures (see Column IV.)—

.521 × 105 = 54.7 weight of ammonium bromide required
.617 × 7 = 4.3 weight of ammonium iodide required

or, practically, fifty-five grains of bromide and five of iodide.

The fifth column is intended for estimating the probable density of the emulsion, as owing to the very different combining equivalents of bromine, iodine and chlorine, their corresponding silver haloids vary greatly in bulk when precipitated from the same quantities of silver nitrate.

TABLE II.

	Ammonium Bromide.	Potassium Bromide.	Sodium Bromide.	Cadmium Bromide (Coml.)	Cadmium Bromide (Anhy.)	Zinc Bromide.	Ammonium Chloride.	Sodium Chloride	Ammonium Iodide.	Potassium Iodide.	Sodium Iodide.	Cadmium Iodide.
Ammonium bromide	1	.823	.951	.57	.72	.87	1.832	1.675	.676	.59	.653	.535
Potassium bromide	1.215	1	1.156	.692	.876	1.058	2.226	2.036	.821	.717	.794	.651
Sodium bromide	1.051	.865	1	.599	.757	.915	1.925	1.761	.71	.62	.686	.563
Cadmium bromide (coml.)	1.755	1.444	1.67	1	1.265	1.527	3.215	2.94	1.186	1.035	1.146	.94
Cadmium bromide (anhy.)	1.387	1.141	1.32	.79	1	1.207	2.542	2.324	.938	.819	.906	.743
Zinc bromide	1.149	.945	1.093	.655	.828	1	2.104	1.925	.776	.678	.75	.615
Ammonium chloride	.546	.449	.519	.311	.393	.475	1	.914	.369	.322	.356	.292
Sodium chloride	.597	.491	.568	.34	.43	.519	1.093	1	.403	.352	.39	.319
Ammonium iodide	1.479	1.217	1.408	.843	1.066	1.287	2.712	2.478	1	.873	.966	.792
Potassium iodide	1 695	1.394	1.612	.965	1.221	1.475	3.104	2.839	1.145	1	1.107	.907
Sodium iodide	1.53	1.259	1.456	.872	1.103	1.332	2.803	2.564	1.034	.903	1	.819
Cadmium iodide	1.867	1.536	1.776	1.064	1.345	1 625	3.42	3.128	1.262	1.102	1.22	1

Table II. will be found exceedingly useful if the operator is desirous of experimenting or substituting one salt for another in a formula. The necessary calculations are seen at once, and a knowledge of chemistry, so far as this part is concerned, is quite unnecessary.

In separate columns are given the relative converting values of each of the soluble haloid salts in ordinary use, showing how much of any salt must be used to replace one grain of any other. Supposing, for instance, we have a formula containing sixty grains of ammonium bromide, sensitized with a hundred grains of silver, and we require to substitute potassium bromide for the ammonium salts. In the first column we find under "Ammonium bromide," opposite to "Potassium bromide," the figures 1.215, the amount required to replace one grain, so that $1.215 \times 60 = 72.9$, the quantity of potassium bromide necessary to replace the sixty grains of ammonium salts. Or again, if we desire to introduce a small quantity of iodide and chloride into the formula without altering the quantity of silver employed—say, five grains each of potassium iodide and sodium chloride—we refer to the column headed ammonium iodide, and opposite ammonium bromide we find the figures .59, and in the like manner we have under sodium chloride 1.675. Therefore—

$$.59 \times 5 = 2.95$$
$$1.75 \times 5 = 8.375$$

or a total quantity of 11.325, which represents the number of grains of bromide of ammonium that must be deducted from the original 60 grains, to make room for the iodide and chloride.

By reading the figures in the contrary direction across the table horizontally they may be taken to represent the relative proportions of silver converted by a given quantity of the different salts. Thus, in the fifth line from the top we find, under the respective headings of ammonium bromide and cadmium bromide (anhyd.), the figures 1.387 and 1; that is to say, the same weight of these salts convert respectively these quantities of silver.

Bromide Emulsion for Dry Plates.—Under this heading will be given the method of preparing an emulsion for dry plates of varying rapidity.

The first consideration is the room to work in. Every possible inlet for light must be stopped up, and a lamp procured of a deep ruby red. If the emulsion to be made be a very sensitive one the least amount of light possible must be used. A clear table to work on is a necessity. Some jars with suitable lids, a pan to hold one of them, and a small Bunsen burner with stand for the pan, will be required. For a slow-working emulsion for landscape work weigh out the following:

1. Potassium iodide ..... 10 grains
2. Potassium bromide ..... 272 grains
3. Nelson's No. 1 photographic gelatine ..... 60 grains
4. Silver nitrate ..... 350 grains
5. Hard gelatine ..... 1 ounce

Nos. 3 and 5 are rapidly washed in water by pouring some on and draining it off again as soon as possible without allowing it to soak up much water, but merely to get rid of any adherent dust.

In two small test tubes place Nos. 1 and 2, and add 3 ounces of water to each. To No. 2 add 2 minims of strong hydrochloric acid, together with sufficient of a solution of iodine in alco-

hol to turn it a deep sherry color. The gelatine No. 3 is then placed in two ounces of water, and when it is properly swollen it should be dissolved. No. 4 is dissolved in an ounce of water, and heated to about 120 deg. Fahr.

We now remove the different solutions to the dark room. The gelatine No. 3 is placed in one of the jars standing in the pan of hot water, and No. 4 added to it. The whole is then shaken up until thoroughly mixed. Three-quarters of the bromide solution No. 2 is then added very slowly, violently stirring the whole time. No. 1 is then added to the remaining portion of No. 2, and the mixture added to the emulsion now formed.

The addition of the bromide to the silvered gelatine is not to be done carelessly. It is of great importance that the mixture should be thorough. For this purpose many contrivances have been made. Fig. 175 illustrates a spray apparatus, easily constructed by bending two thin glass tubes in the manner shown. The end of the tube A should then be drawn out until quite closed; with a file the point is then filed away until a small orifice is obtained. The two tubes are fitted with the cork inserted in the bottle. The bromide is placed in the bottle, and a fine spray can be forced through the orifice of the tube A by blowing down the other tube, insuring a more equal division in the emulsion.

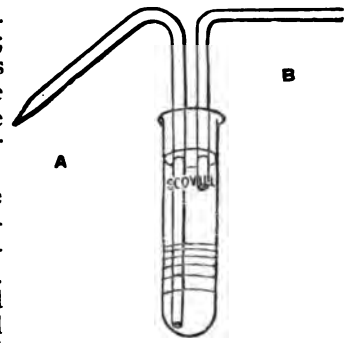


FIG. 175.

A small drop of the emulsion should next be placed on a piece of glass, and should appear of a ruby color when examined by gaslight looking through it. The pan containing the jar with the emulsion is now placed on the Bunsen burner, and the flame lighted. The water is then brought to boiling point, and the emulsion boiled for about three-quarters of an hour. The jar containing it should be shaken every ten minutes or so. When boiled for the required length of time the pan is removed. It will be seen that we have still the hard gelatine No. 5 unused. This is placed in four ounces of water, allowed to swell, and dissolved at a temperature of about 100 deg. by immersing in the pot containing the hot water. The emulsion and this gelatine are then cooled down to a temperature of about 70 deg. to 80 deg., and added together. A thorough mixture must be made by violently shaking. When the froth thus produced has subsided the emulsion is poured out into a flat porcelain dish, quite clean, and then laid away in a dark place to set, which should require about one hour in winter and two or three in summer.

When thoroughly set it should be carefully scraped from the dish with a piece of clean glass, and laid on to a piece of coarse canvas netting, which has been boiled to rid of dirt or greasy matter.

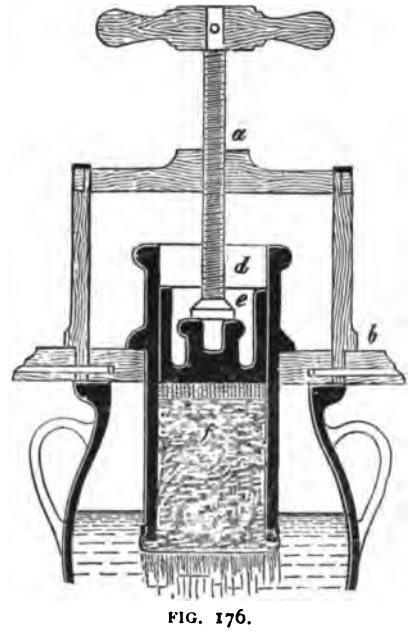


FIG. 176.

This figure will give some idea of the kind of material required. When all the emulsion is collected from the dish and placed in the netting the latter is twisted up, and the emulsion squeegeed through the openings of the netting into a vessel containing water, the whole being kept below the surface the whole time. The emulsion is thus broken up into little strips in the water, which soon has the desired effect of dissolving the soluble salts from the emulsion. For large quantities of emulsion a more convenient manner for breaking up the emulsion is shown in Fig. 176. It consists of a piston in a cylinder. In the cylinder is placed the emulsion, and at the bottom is pitted a piece of silver wire gauze. The piston is then made to force the emulsion through the interstices. After the gelatine emulsion has thus been broken up, it is well washed in a running stream of water. Fig. 176 gives a plan for effectually washing it. It will be seen to consist of a tin case, made quite light-tight, into which is placed the glass containing the emulsion. The direction of the arrows shows the flow of water continually passing through it. The advantage of this apparatus is that, being light-tight, it can be used in the daylight if necessary. For small quantities of emulsion an earthenware teapot can be used, and a current of water sent down the pipe.

Two or three hours' washing should suffice. The emulsion is then thoroughly drained, and is ready for melting. This should not be done if the emulsion be sloppy. By pouring a few ounces of alcohol before draining on to it it will become firmer. When drained the emulsion is transferred to the jar, and this placed in boiling water until the emulsion is dissolved. Half a grain of chrome alum and six drachms of absolute alcohol are now added, and it is ready for filtering. Chamois leather makes the best filter, although it is difficult to force the emulsion

through. An apparatus similar to that depicted in Fig. 176 is used. A small pneumatic ball at the top enables the operator to force the emulsion out of the top flask, through two thicknesses of chamois leather tied to the bottom, into the flask beneath. The emulsion when filtered is ready for coating and making dry plates. For instructions regarding this part of the process see **Dry Plates.**

Bromide Emulsion for Rapid Plates.—With the formula of the emulsion just given a few good dry plates may be made for ordinary work where rapid exposures are not required. If the plates, however, are required for instantaneous work, it will be necessary that an emulsion be specially prepared for the purpose. Sensitiveness in an emulsion may be obtained by several different methods. Charles Bennett, in 1878, prepared a sensitive emulsion by heating it to about 90 degs. Fahr., and keeping it at that temperature for five or six days. In the followlng year, however, Mr G. Mansfield proved this tedious process to be unnecessary, as by heating the emulsion in boiling water he obtained the same degree of sensitiveness in a few minutes, instead of days. A high sensitive condition is only obtained when soluble bromide is in excess in emulsion, and only when in the presence of gelatine. When the emulsion is first formed it has an orange color, when viewed by transmitted light, and the emulsion if used then will absorb the blue rays and transmit the red rays, the work of forming the image being done by the blue rays. When the emulsion is cooked, however, to obtain extra sensitiveness, it becomes of a cold, gray color by transmitted light, and yellowish green by reflected light, showing that the yellow and red rays are absorbed, and some of the blue rays transmitted; but curiously enough, however, this emulsion is more sensitive to the blue rays than the other. Abney explains this curious phenomenon in his work on emulsion processes* in this manner: He says it is not owing to the fact that the silver salt is slightly sensitive to the yellow rays, for this would only increase the sensitiveness by about one-twentieth, as photographing the spectrum shows us. It must be recollected that the apparent color of the bromide may be produced in two ways, or, rather, that it may be due to two causes. It may be due to the color of the bromide itself, which is what we call its molecular color, or a variation in color may be due to the scattering of light by the different sizes of the particles, each particle being in all probability composed of thousands of molecules. When an emulsion is boiled, an inspection of the film after different lengths of boiling will convince us that the longer an emulsion is boiled the larger the size of the particles which are imbedded in the gelatine. Hence boiling produces large particles. The cause is probably that siver bromide is slightly soluble in water, and much more in water containing soluble bromide. Without doubt some portions of the silver bromide are so dissolved and re-precipitated on the coarser particles or other portions of the finer bromide being taken up, and they in their turn deposited, and so on

In an emulsion of this kind the proportions of the soluble bromide and the silver nitrate exercises a very important influence over its character. The larger the excess of soluble bromide, the quicker is the silver bromide converted, and a much shorter cooking will be required to an emulsion which has but little excess.† There is, however, a limit to the amount of excess, which, if too great, would tend to form fog, very difficult to get rid of. The following rapid gelatino-bromide emulsion, by Mr. Wilson, gained the prize in the Paget competition of 1880. The description of the process is thus given:

To make a pint of emulsion, select a twenty-ounce narrow mouth stoppered bottle, with a well-fitting stopper and thin bottom. Make it perfectly and thoroughly clean.

Make a stock solution of—

Hydrochloric acid (pure).....1 fluid drachm.
Distilled water.....12½ ounces.

Place in the 20-ounce bottle—

20 mimims of the above dilute acid.
3 fluid ounces distilled water.
210 grains of ammonium bromide.‡

‡ Potassium bromide will be found to be superior. It must, however, be obtained neutral.

80 grains of Nelson's No. 1 photographic gelatine.

Allow the gelatine to swell for about fifteen or twenty minutes. The addition of the small quantity of diluted hydrochloric acid to the soluble bromide and gelatine is recommended in the formula given for the following reasons:—If the soluble bromide be absolutely neutral and the gelatine of good and suitable quality the trace of hydrochloric acid is quite unnecessary and had better be omitted. With gelatine, however, that is slightly alkaline or apparently neutral, but does not give a clear solution the addition of the acid solution is necessary. In order to ensure a fine precipitate the bromised gelatine solution should contain a trace of hydrochloric acid, and the sliver solution should not be stronger than 110 grains per ounce. If it be a solution of from 50 to 60 grains per ounce it may be poured in all at once. Mr. Wilson considers that the elaborate apparatus constructed for this purpose is quite unnecessary.

* PHOTOGRAPHY WITH EMULSIONS, by Captain W. de W. Abney, F.R.S.

† Abney is of opinion that if exactly the equivalent quantities could be used no possible amount of cooking would give the sensitive condition.

With regard to the quality of the gelatine to be used, something has already been said, and further information on the best gelatines for emulsion work will be found under **Gelatine.** A good test for the suitability of the gelatine for this process is to add the silver, and see if a fine precipitate can be obtained without the necessity of adding the hydrochloric acid. If the quantity of the latter be too large it will retard the conversion of the silver bromide into the sensitive form in cooking, and also has a destroying action upon the gelatine, so that it will be obvious to the reader that the addition of this small quantity of hydrochloric acid must be done thinkingly and according to the quality of the other materials. The silver used should be of good quality. It is usually slightly acid, with an excess of nitric acid, and can be used in this condition. Better results are, however, obtained by utilizing the silver solution with sodium carbonate. By so doing the condition of the silver can be made to be always the same, and the presence of nitric acid in the emulsion, producing a tendency to various discolorations in the finished negative is, avoided.

In a perfectly clean glass measure dissolve 330 grains of silver nitrate (re-crystallized) in three ounces of water (distilled).

Pour about two fluid drachms of this silver solution into another vessel, and dilute it with an equal quantity of distilled water.

Now remove the 20 ounce bottle and the two silver solutions to a dark room, in which all the subsequent operations are carried on. The light should be as non-actinic as possible. Mr. Wilson prefers a paraffin lamp, protected with one sheet of ruby and one sheet of dark orange-yellow glass.

In the dark room should be fitted a gas boiling-stove, with a saucepan of convenient size to contain the 20-ounce bottle when the lid is placed on. The pan should be fitted with a tin perforated false bottom to prevent the bottle resting on the bottom of the saucepan. The pot should contain three or four inches of boiling water. The gas of the stove should then be turned out, and the bottle plunged into the water two or three times until it is heated (this is to prevent cracking it), and then leave it in the saucepan for a little time to allow the gelatine to become dissolved. Immediately it is dissolved remove the bottle, shake up the contents, and place the bottle near the light for better convenience. Add the four drachms of dilute silver solution by pouring it in all at once, then shake it well up for about a minute or so. The second strong silver solution is then added in small quantities of three or four drachms, well shaking the emulsion during the addition, and giving it a final thorough shaking afterwards for about two or three minutes. Provided these instructions have been carefully carried out there should be no coarse precipitate in the finished emulsion.

The emulsion now complete, the next process is to render it sensitive. The bottle containing it is returned to the hot-water pan, the cork containing a slit to allow of the escape of hot air is fitted in, and the saucepan lid covered over the whole. Light the gas burner, and when the water is brought to a boil keep boiling for fifty-five minutes. At the expiration of this period turn out the gas, and remove the bottle and cool it down as quickly as is consistent with safety, care being taken that the bottle is not cracked in the operation. In winter it should be stood on a table for ten or fifteen minutes, and then cooled with water. Another way is to leave the bottle in the saucepan containing the hot water, and allow a little cold water to flow slowly in the pan, gradually cooling it. The bottle should be shaken up now.

In a 16-ounce glass beaker put one ounce of Nelson's No. 1 photographic or X opaque gelatine, and pour over it ten ounces of clean water. Allow it to remain until the gelatine has absorbed four ounces of the water, then pour off the remaining six ounces, and melt the swollen gelatine by placing the glass beaker in the hot water pan. When dissolved pour it into the 20-ounce bottle containing the cooled emulsion, shake up well so as to thoroughly mix, and then pour the whole back into the beaker. Place this in a cool part of the room, and leave it for about a day. It is recommended that the addition of the gelatine to the boiled emulsion should be made when both are at a low temperature, and during the period between the addition and the washing it should be kept at as low a temperature as possible, for the reason that the excess of alkaline bromide has a most destructive effect upon the gelatine last added, and the lower the temperature and quicker the time in which the two are in contact the better. Another rather curious effect in the addition of the second quantity of gelatine should be noted. If the temperature be cold the plates will dry with a matt surface; the higher the temperature the richer the gloss obtained.

We now come to the washing of the emulsion. This should be done in clean cold water. Mr. Wilson's instructions are:—In a glazed earthenware vessel place about three pints of cold water, and add to it three ounces of a saturated solution of potassium dichromate. When the emulsion is cooled down, and is quite firm, it is squeezed through the canvas in the manner described in the last emulsion formula; or the emulsion may be washed by precipitating with alcohol, squeezing the clot, breaking it up, and soaking it in water. After squeezing through the meshes of the canvas held under the surface of the water, the emulsion is allowed to remain for about an hour, when the operation is repeated a second and a third time in a further supply of cold water. After the last straining the emulsion is placed in a large beaker standing in warm

water, and heated to a temperature of about 115° Fahr. The emulsion should now measure about 16 or 17 ounces. Add to it two ounces of alcohol and mix thoroughly; next place in a measure, and if less than 20 ounces make it up to that quantity by the addition of clear water. The emulsion is now ready for filtering and coating the plates. In the absence of a proper filter for this purpose, place a small tuft of cotton-wool in a glass funnel, and allow the emulsion to run through this.

Bromide Emulsion with Ammonia.—In the two foregoing emulsion processes for dry-plate bromide emulsions, the emulsion undergoes a cooking process. In the methods now to be described, instead of boiling, the emulsification is produced by treating with ammonia. This plan is originally due to Dr. Van Monckhoven, and has been brought to a more perfect state by Dr. Eder and others. Eder's process with ammonia is thus given by him :* Dissolve 370 grains of chemically pure air-dried potassium bromide in 10½ ounces of water, and add from 520 to 700 grains of gelatine, and, after soaking for about 15 minutes, the pot containing the whole is dipped in a water bath, and the gelatine dissolved and raised to a temperature of about 95° or 120 Fahr. Next dissolve 460 grains of silver nitrate in 10½ ounces of water, and add ammonia drop by drop until the precipitate at first formed is dissolved, and the solution becomes quite clear. The two solutions are now removed to the dark room, and the silver solution gradually added to the gelatine solution, which should now be cooled to about 75°, shaking frequently, and finally rinse the the remains of the silver out of the bottle with one ounce of water, and add to the emulsion. Then replace the jar containing the emulsion in the water bath, which should have a temperature of 75° Fahr. (not more), and allow it to remain in this for a quarter-of-an-hour, gradually cooling the emulsion to about 75°, but not lower, or the gelatine will set. The salts and the gelatine do not require to be so carefully chosen for this method as for that which follows. Should the bromide of potassium have an alkaline reaction, it does no harm, neither is the neutrality of the nitrate of silver imperative, nor the acidity of the gelatine which may be alkaline. The reason is that, without these requirements, the method is adapted to the alkaline reaction, which would be neutralised by the ammonia. The specific gravity of the emulsion regarded as determining its strength is a secondary consideration. Take a strong solution of ammonia. As one is deprived of any indication by which to regulate properly the addition of ammonia in adding it to the gelatine containing potassium bromide (instead of to the nitrate of silver), this process is not to be recommended.† Care must be taken that the temperature does not exceed 105° Fahr. when adding the ammoniacal silver solution or during digestion. After digestion the emulsion is allowed to set, pressed through coarse canvas, and washed in several changes of water for one or two days, suspended in a coarse stuff bag. As a great deal of water adheres to the gelatine particles it should be allowed to drip for at least half-an-hour, otherwise the emulsion will be too fluid. The finely-divided emulsion may be deprived of water by placing it in a bath of alcohol, and then dried in the air for future use, or it may be immediately liquefied by heating in the water bath. After filtering it is ready for use. If, however, it is intended to be kept, an antiseptic must be added. To every ten ounces of emulsion add ten grains of salicylic acid dissolved in one drachm of alcohol, or replace the salicylic acid by the same weight of thynol oil, as a protection of the gelatine against the change caused by keeping the solution warm for so long. The alcohol has also a favorable action, accelerating the setting of the gelatine and the drying of the film.

Bromide Emulsion by Boiling and Subsequent Digestion with Ammonia.—Dr. Elder has also a second method slightly more complicated than the last. It is based on the observations that the modification of bromide of silver, which transmits blue light, is produced very rapidly at a temperature at from 140° to 212° Fahr., and, further, that the sensitiveness of such emulsion can be increased by subsequent treatment with ammonia at a gentle heat, while if the boiling were continued fog would be produced. The proportions of the various ingredients required are the same as those just given in the method with ammonia. After mixing the emulsion it is boiled in a bottle placed in a light-tight tin saucepan to prevent even the light from the spirit lamp beneath the pan reaching the emulsion. The emulsion is now highly sensitive, and can be used in this condition. When it has become quite cool (70° Fahr.), however, its sensitiveness can be highly increased by adding two drachms of liquid ammonia ·880, and placing it in a water bath of from 95° to 100° F., and digesting it at this temperature for from half-an-hour to an hour. It is then set and washed in the manner already described. With regard to these two methods of Eder's, it may be stated that the first is more suitable for hard negatives, and the second for a softer image and where greater rapidity is desired. In the preparation of this second method, however, great care must be exercised. The gelatine should not have an alkaline reaction, or fog will be produced in boiling.

Monckhoven's Emulsion Process is given by him in these words: "I prepare very pure and dilute hydrobromic acid, and I determine accurately the exact quantity of it necessary to precipitate exactly 150 grains of silver nitrate. I then dissolve this amount of acid in seven ounces

* See *Photographic Journal*, 1890 ; and "Eder's Ausfühliches Handbuch der Photographie."

† When gelatine, bromide of potassium and ammonia are dissolved, and the nitrate of silver is then added, the ammonia should not be allowed to act too long upon the gelatine. The ammonia is best added immediately before the addition of the nitrate of silver to the gelatine.

of water, and afterwards add to it 40 grains of gelatine, and evaporate by heating. I now remove to the dark room where all the subsequent operations take place, and here I precipitate 130 grains of silver nitrate by a very slight excess of sodium bicarbonate. I allow this to settle for twenty-four hours, and then renew the same amount of water, after which I allow it to settle previous to decanting. On this precipitate of silver carbonate I pour a hot solution of gelatine, made by dissolving 30 grains of it in 70 ounces of water. This I stir well up, and pour on the solution of hydrobromic acid. The mixture is thoroughly shaken every quarter-of-an-hour, and kept at a constant temperature of 120° F. The silver carbonate will slowly dissolve in the hydrobromic acid, and the silver bromide is formed in the colloidal liquid in a state of extreme sub-division. At the expiration of from ten to twelve hours, the mixture, if flowed over glass, would have a greenish-white color. I next introduce 150 grains of gelatine cut into very thin shreds, and this I dissolve by stirring, and when dissolved I flow the emulsion over the glass plates without any washing."

Henderson's Emulsion Process.—This process may be considered to be a modification of the cold emulsification method. The formula is as follows :—Ten grains of gelatine are dissolved in one ounce of water by gentle heat, and add—

Ammonia carbonate*	20 grains.
Potassium bromide	150 grains
Potassium iodide	2 grains
Alcohol	3 ounces
Ammonia ·880	60 minims

The ammonia and alcohol are mixed together before adding to the gelatine. When quite cold stir in—

Silver nitrate	200 grains.
Water	2 ounces.

Shake it up occasionally, and in about an hour it will be quite ripe enough for ordinary purposes. The maximum sensitiveness is reached in about ten or twelve hours ; further than this no action seems to take place.

The convenience of this method is that a large stock of the above emulsion can be made and kept for use at different times as required.

For use take for the above quantities from four to five drachms of dry gelatine and warm gently to dissolve. When this occurs stir in 12 ounces of methylated alcohol heated to a temperature of about 100°. When cool the emulsion will precipitate on the bottom of the vessel, and it is then broken up and well washed in a running stream from two to twelve hours. Make up bulk to eight to ten ounces. Gelatine dissolved in alcohol, ammonia and water will not set so firmly as the same amount of gelatine and water, yet if the salts and ammonia are removed by precipitation with excess of alcohol the gelatine recovers its setting powers. One of the chief drawbacks to this method is the large quantity of alcohol required.

Bromide Emulsion Process by Cold Emulsification without Ammonia.—This is a process described by Mr. Cotesworth. An ordinary emulsion is allowed to gain sensitiveness by remaining liquid at ordinary temperatures. Other similar methods have been devised in which the emulsification takes place at a low temperature in gum Arabic or other similar substance. The process cannot be said to be perfect. No further description of it will, therefore, be given.

Bromide Emulsion by Precipitation.—This process was described by Captain Abney. It is a method of preparing an emulsion by adding *washed* silver bromide. The following are the eminent scientist's instructions.† Let us suppose we are going to make up about seven ounces of gelatine emulsion.‡ Weigh out 40 grains of ammonium bromide (or its equivalent in zinc potassium or any other bromide), and dissolve in 20 ounces of water. Next weigh out 250 grains of silver nitrate, and dissolve in six ounces of water, and add six drachms of glycerine to it, and stir thoroughly with a glass rod. We prefer to put this mixture in a glass jar holding about 40 ounces. The bromide solution should now be added very cautiously. Take a ten-ounce measure, and fill it up to six ounces or thereabouts, so that it is not too full, and gradually drop, little by little, the solution into the silver solution, stirring very thoroughly the whole time. A milky emulsion forms, and gets thicker and thicker, till the whole bromide in the 20 ounces is added, though of course the fluid is *per se* thinner ; a quarter of an ounce of nitric acid is then added and well stirred up. This addition is made to prevent fog, which might be caused by the excess of silver present.

This emulsification is better carried on in a dark room, though this is not absolutely necessary. *The bromide solution must be poured into the silver solution, and not* vice versa, *or a failure will be most probable.* The glass jar and its contents are now placed in a cupboard and left for as long a time as convenient, but not for less than a quarter of an hour. By the latter time the silver bromide will have fallen to the bottom of the jar with the exception of a very slight milkiness, which will subside in a couple of hours. The quantity of silver bromide left in suspension after

* The ammonia causes effervescence. † See Abney's "Photography with Emulsion." ‡ See under Emulsion calculations.

a quarter-of-an-hour is, however, so small that it may be decanted off without detriment to the emulsion. The jar is tilted and the liquid poured gently off, or a syphon may be used, and the liquid syphoned off close to the precipitate at the bottom. Next pour 20 ounces of water into the jar, stir the precipitate well up, and again allow it to subside. As soon as subsidence takes place, the water is again decanted or syphoned off. Repeat this operation three or four times, and test the water for acidity with blue litmus paper, and for silver nitrate by adding one drop of potassium chromate. A red coloration indicates the presence of silver nitrate. If either be present, the washing must be continued until freed.

The second part of the process has now to be described. 100 grains of Nelson's No. 1 photographic gelatine are soaked in two ounces of water, and another 100 grains of a harder gelatine, such as Autotype or Henrich's hard gelatine, soaked in three ounces of water. The No. 1 gelatine when soaked is taken up on a rod and the vessel containing the precipitate is placed in hot water, and the gelatine used as a mop to collect it. The gelatine gradually melts, and the bromide becomes emulsified. It is then transferred to a flask heated in boiling water for about five minutes, and well shaken up. When all the froth has subsided the bottle is again shaken, and the warming process repeated. After two or three such shakings a little of the gelatine emulsion may be dropped upon a glass plate, and examined for granularity. If absent, so much the better; but if present, half the second lot of the harder gelatine, which has meanwhile been dissolved, must be added.

If this emulsion be raised to boiling point for five minutes, then shaken, and the operation repeated a second time, a fairly rapid emulsion is obtained. When ready, the remainder of the gelatine solution is added, together with half an ounce of alcohol, and after a final shake the emulsion is filtered through washed cotton-wool, and is ready for the coating operation.

Another method of emulsification is by separation with a centrifugal machine. See **Separation.**

Bromide Emulsion for Paper.—Although almost any of the bromide or iodo-bromide emulsions may be satisfactorily used for coating paper for printing out or enlarging, yet in the opinion of the author the following formula is the most suitable. It is a slow emulsion used for coating plates for landscape work, and was first given by Mr. W. K. Burton. The author has added a small quantity of glycerine to make the film less brittle when dried on the paper support:—

A	Silver nitrate	200 grains
	Distilled water	3 ounces
B	Potassium bromide	160 grains
	Potassium iodine	10 grains
	Nelson's No. 1 gelatine	40 grains
	Water	3 ounces
	Hydrychloric acid	2½ minims
C	Hard gelatine	150 grains
D	Hard gelatine	150 grains
E	Glycerine	1 drachm
	Alcohol	½ ounce

The gelatine of B is allowed to soften, at the same time water may be poured over the gelatine C and D, and allow them to swell separately. A and B are now heated to 120° Fahr., and A is poured into B slowly with vigorous stirring. The emulsion thus formed is allowed to stand ten minutes with occasional stirring. In the meantime as much water as possible is squeezed out of the gelatine C by wrapping it up in a piece of cloth and wringing the cloth round. In ten minutes the emulsion (having been allowed to remain without stirring at least two minutes to allow any granular bromide which may have been formed to subside) is poured over C, heat being, if necessary, applied to melt the gelatine. When the gelatine and the emulsion are thoroughly mixed, the jar containing them is set on one side to allow it to set in a stiff jelly. It is then squeezed through canvas and washed. When thoroughly washed D (having had as much water as possible wrung out of it) is added. It is then melted up, well mixed, and E added. It is then ready for coating the paper for the production of bromide paper, for positive printing or for negatives. For the latter, however, one of the quicker emulsions is more suitable.

Chloride Emulsion.—In this emulsion we have chloride instead of bromide of silver. The rapidity of the emulsion is thereby lessened, but it is most suitable for the production of lantern slides or transparencies.

SOLUTION No. 1.

Sodium chloride*	160 grains
Nelson's No. 1 gelatine	60 grains
Hydrochloric acid	10 minims
Distilled water	3 ounces
Glycerine	4 drachms

* Instead of sodium chloride other chlorides may be used. Ammonium chloride gives softer pictures, but should be used in the form of powdered crystals, sold as sal. ammoniac. It should be dried before using, however.

The gelatine is first soaked, then dissolved, and the other ingredients added.

SOLUTION No. 2.

Silver nitrate	400 grains
Distilled water	1 ounce

SOLUTION No. 3.

Nelson's No. 1 gelatine	60 grains
Distilled water	2 ounces

SOLUTION No. 4.

Hard gelatine	200 grains
Nelson's gelatine	80 grains
Distilled water	4 ounces

Soak Nos. 3 and 4, and dissolve slowly by heat. No. 2 is then added to No. 3 at a temperature of about 100 deg. Fahr., and added very gradually to No. 1, rapidly stirring. Shake the bottle containing it well up, and when nearly cool add No. 4 solution, and the emulsion is ready. This is not a rapid emulsion, and for transparency work this is not necessary. Greater rapidity can be given to it, however, by boiling for half an hour or an hour before the addition of solution No. 4.

Chloro-bromide Emulsion.—A gelatine emulsion containing a chloride and a bromide; and used for printing direct or enlarging by exposure and subsequent development, as with the latter emulsion. The following formula for the emulsion was given by Wellington about the year 1885. The advantage it is supposed to possess is that warmer tones may be obtained than with an emulsion containing bromide only.

Two solutions are made up—

SOLUTION No. 1.

Silver nitrate	100 parts
Citric acid	100 parts
Water	1440 parts

SOLUTION No. 2.

Sodium chloride	20 parts
Potassium bromide	40 parts
Citric acid	100 parts
Gelatine	40 parts
Water	1440 parts

Both solutions are heated to a temperature of about 150 deg. Fahr., and solution 1 is added slowly to solution 2, shaking it well up; 200 parts of gelatine, soaked, drained and melted, are then added, and the emulsion poured into a dish to set. On the next day it is washed. The emulsion is then melted, and should measure about 4,800 parts. It is now ready for spreading on to glass or paper.

Aceto-gelatine Emulsion.—A patent was taken out by Vogel for the production of an emulsion which should combine the rapidity of the ordinary gelatine plate with the ease of coating of a collodion emulsion. An ordinary emulsion is dried, and the pellicle dissolved in one of the fatty acids, such as formic, acetic or propunic (acetic acid is preferable, owing to its cheapness). About three times the quantity of acid is added to the pellicle, and gently warmed until the latter is dissolved. A sufficient quantity of alcohol is then added, till it is of a proper consistency for flowing over the plate when heated to a temperature of about 90 deg. Fahr. When cold the emulsion sets in a gelatinous mass. Plates may be coated in the same manner as with collodion. To give greater tenacity to the emulsion Vogel mixes pyroxyline with it, his formula being—

Pyroxyline	20 grains
Acetic acid	1 ounce
Alcohol	1 ounce

This is mixed with an equal quantity of the gelatine emulsion. Plates coated with it may be used either wet or dry.

Chloride Emulsion (*Printing-out*).—This is an emulsion of a different character to any of the preceding. In this the silver bromide or chloride is formed, with an excess of the salt afterwards washed out. The image is produced by a short exposure, and made visible by development. In this class of emulsion, however, we have an excess of silver formed into silver citrate, and the image is formed visibly by prolonged exposure—somewhat less than required for albumenised paper. As this emulsion contains a large percentage of citrates, it is also termed a "Citro-chloride of silver emulsion."

Various formulæ for the production of the emulsion have been given. Abney's process is thus described by him. The original method of preparation is as follows:—

No. 1.—Sodium chloride		40 grains
	Potassium citrate	40 grains
	Water	1 ounce

No. 2.—Silver nitrate ..... 150 grains
Water ..... 1 ounce

No. 3.—Autotype gelatine ..... 320 grains
Water ..... 3½ ounces

Nos. 3 and 2 are mixed together, and an emulsion formed by adding No. 1 in the usual way when forming a gelatine emulsion

Ashman and Offord give the following modification of the above:—

A.—Ammonium chloride ..... 53 grains
Gelatine ..... 420 grains
Water ..... 20 ounces

B.—Silver nitrate ..... 150 grains
Water ..... ½ ounce

C.—Sodium citrate ..... 30 grains
Gelatine ..... 100 grains
Water ..... 3½ ounces

D.—Silver nitrate ..... 45 grains
Citric acid ..... 80 grains
Water ..... ½ ounce

The gelatine A is one-third soft and one-third hard, that in C is all hard; A and B of the solution of each are mixed to form the emulsion. When set it is squeezed through canvas and washed. C and D are emulsified together, and kept at as low a temperature as possible, and then slightly washed. The two emulsions are mixed together, and 15 grains of citric acid are added.

Henderson has a method somewhat different to the above. He dissolves 16 parts of gelatine, 11½ parts of sodium acetate in 1,200 parts of water, and adds 42 parts of silver nitrate dissolved in 480 parts of water, and also five parts of sodium chloride and 7½ parts of sodium citrate, dissolved in 480 parts of water. Lastly, 480 parts of swollen and dissolved gelatine are added, and the quantity of the whole made up to 4,300 parts by the addition of more water. Without washing the emulsion is ready for coating.

Papers prepared with printing-out emulsions of these descriptions are now largely sold under various names, such as Celerotype, Aristotype, Obernetter, etc. They are usually kreide or baryta paper, coated over with a thick film of the emulsion. The paper prints much more rapid than ordinary albumen paper, especially in winter, as it is particularly sensitive to the green ray, and does not rely upon the ultra-violet rays of the spectrum, which are almost deficient in winter. It is also believed that prints upon emulsion paper of this description will last much longer than albumen prints, as the organic salt is a definite compound, and not so complex or uncertain as the albuminate of silver.

EMULSION (COLLODION).—See under **Collodion Emulsion, Collodio-chloride Emulsion, Collodio-bromo Chloride Emulsion, Collodio-citro Chloride Emulsion, Collodion Albumen Emulsion.**

EMULSION PRESERVATIVES —See **Preservatives.**

EIKONOGEN.—A name given to a new substance, discovered by Dr. Andresen, of Berlin, having a developing action upon dry plates and bromide paper. Chemically it is the sodium salt amido-β-napthol--βsulphonic acid, having the formula

$$C_{10} H_8 O_4 Na S + 2H_2 O.$$

Andresen found by experiment that certain substances—diamidonaphthaline, amidonaphthol and dioxynaphthaline, as well as their sulpho-acids, are exceptionally suitable for developing photographic pictures produced on sensitive plates, and give results equal to those obtained with an alkaline pyrogallol developer, excelling the latter by giving the plates a blue-black tint similar to that produced when developing in a bath of oxalate of iron, without in the least coloring the sensitive plate, but enabling it to better resist the alkaline action of the bath. For instantaneous photography the inventor recommends a developer composed of the following ingredients:

Eikonogen ..... 5 grammes
Sulphite of soda ..... 15 grammes
Distilled water ..... 250 grammes
Potash ..... 5 grammes

Instead of potash, soda of carbonate, soda lye or potash lye may be used, in which case it is preferable to replace the 5 grammes of potash by 20 drops of a concentrated or saturated soda or potash lye.

The formula for using eikonogen is, like its action, closely analogous to hydroquinone. One of its chief advantages over other developing agents is in the fine and delicate bluish-black deposit. This beautiful color, which the images therefore assume, makes this developer

particularly suitable for lantern slides and transparencies. For negative making it is also recommended on account of its action of bringing out the finest detail in a clear manner.

Eikonogen is old commercially in the form of yellowish white crystals, soluble in water, but unsoluble in alcohol. An aqueous solution soon becomes brown by oxidation. The addition of sodium sulphite causes it to turn green instead of brown. It possesses the advantage over pyro of being non-poisonous.

For bromide contact prints and enlargements, it is a very suitable developer. It is very clean, and the liability to stain is diminished. The following two formulæ have been tried successfully:

FORMULA NO. 1.

SOLUTION A.

Distilled water, heated to 104 degs. F.	500 parts
Sodium Sulphite (pure)	50 parts
Eikonogen	8 parts

SOLUTION B.

Distilled water	500 parts
Sodium carbonate	25 parts
Potassium carbonate	25 parts

In developing, equal parts of both A and B solutions are mixed, or the quantities regulated according to the qualities of the exposed plate.

FORMULA NO. 2.

SOLUTION A.

Sodium sulphite	15 grains
Eikonogen	7½ grains
Water	1 ounce

SOLUTION B.

Potassium carbonate	80 grains
Water	1 ounce

For use, add six parts of solution A to two or three parts of solution B.

The solution can be used over and over again until it becomes exhausted, when it can be revived by the addition of a little of the fresh solutions.

ENAMEL ALBUMEN PAPER.—A name given to a thickly-coated albumen paper.

ENAMEL COLLODION.—A plain collodion used for giving a protective film to prints or negatives. The following will be found serviceable:

Pyroxyline	12 grains
Alcohol	1 ounce
Ether	1 ounce
Castor oil	2 drops.

ENAMELLING.—A method of giving prints made upon smooth paper a brilliant polished surface, superior to that finish obtained by burnishing. This is effected by coating the print with a film of collodion, which not only gives it a brilliant surface, but also acts as an excellent protector.

A glass plate is thoroughly cleaned and dusted over with French chalk. This is rubbed over the glass with a tuft of cotton wool, and with another piece of wool lightly removed. The plate is then coated with enamel collodion (see **Enamel Collodion**), and having made up a gelatine solution consisting of 10 or 12 grains to the ounce of distilled water, place it into a dish and insert the collodionized plate and the print. Next lay the print face downward into contact with the film side of the coated plate, and remove together from the solution. Squeegee into optical contact, and allow it to dry. When dry it will not be a difficult matter to remove the prints from the glass by raising one corner with a knife, inserted between the collodion film and the glass. The collodion film adheres to the print, and leaves the glass with a very high polish.

With gelatine printing papers, such as celerotype, aristotype, or bromide and chloride developed papers, the process may be somewhat simplified. The glass plate is clean and dusted over with the French chalk. The gelatine prints are then removed from the final washing water and laid face downward upon it. With a squeegee they are pressed into contact, and when dry they will leave the glass with a brilliant surface. The collodion film and the gelatine solution are, therefore, dispensed with, but the gelatine polished surface obtained in this manner is much more easily affected by moisture than the collodion surface.

Instead of glass the prints may be squeegeed on to polished ebonite, celluloid, or on to ferrotype plates.

ENAMELLED IRON.—Iron covered over with a vitreous surface. Photographic dishes and other utensils made of enamelled iron are extensively sold. The drawback to their use is

chiefly in the fact that the effect of heat is to expand the metal more than the enamel, which consequently peels off. Another fault is often in the incompleteness of the enamel surface, which sometimes contains very fine holes. A good way of testing for these is to fill the enamelled vessel with a solution of copper sulphate. The acid will attack the iron wherever it can reach it through the small pores, and little beads of copper are deposited in small spots, gradually increasing in size until they become plainly visible. Dishes containing such holes in the enamel would, of course, be of little use for many photographic operations.

ENAMELOID.—A commercial preparation used as a dead black varnish for blackening lens mounts, diaphragms, etc. It is apparently a celluloid dissolved in acetine and vegetable black added. See **Dead Black.**

ENAMEL PAPER.—Paper with a glazed metallic coating. Various metallic pigments that will spread quickly and take a polish are employed. Of these are white lead, zinc oxide, sulphate of barytes, china clay whiting and chalk laid on in a menstruum or upon a previous coating of glycerine, size, collodion, varnish, etc., and afterward polished with agate or between calendering or burnishing cylinders.

ENCAUSTIC PAINTING.—An old method of painting in which wax was used with the colors in order to give them greater gloss and preserve from injury.

ENCAUSTIC PASTE.—A paste giving a brilliant surface to finished prints without the necessity of using burnishers, hot rollers, or collodion. Among the various formulæ published the following, recommended by Salomons, is probably the best :—

Pure white wax	500 grains
Gum elemi	10 grains
Benzole	4 drachms
Essence of lavender	6 drachms
Oil of spike	1 drachms

First melt the wax and elemi, and then add the benzole and other ingredients, and allow it to cool, stirring frequently. A little of the paste is rubbed over the surface of the print with a piece of soft flannel or cotton wool, and then polished with a clean piece of either material until it is quite free from markings. It increases the brilliancy of the surface, and appears to give a greater depth of shadow, and improves the general beauty of the picture.

ENDEMANN'S PROCESS.—An anilin black printing process. The paper used should be well sized with an aqueous solution of gelatine in proportion of one to fifty. The sensitizing solution consists of

Sodium chloride	48	grammes
Potassium bichromate	48	grammes
Sodium vanadiate	0.10	grammes
Distilled water	960	c.c

Another solution is made of

Sulphuric acid	96 c.c.
Water	480 c.c.

When this is cold it is added to the first solution ; the paper is floated on the mixture, and allowed to dry in a dark place. When dry, or while slightly damp, it is exposed under the negative in a printing frame for about seven minutes, after which it is kept in the dark until developed, which is done by exposing it to a mixture of the vapors of anilin and water for about a minute, after which it is placed in an atmosphere of water vapors kept at a temperature of from 24 deg. C to 30 deg. C. The image is thus developed in black lines on a green ground. To remove a green color the paper is soaked in a one-to-six solution of ammonia.

ENERGIATYPE.—A process discovered by Hunt.

ENGRAVING—See **Photo-engraving.**

ENLARGING.—The operation of obtaining a larger image of a negative or a positive upon a sensitive surface of some kind. There are a large number of methods of enlarging, differing firstly in the method employed, and secondly in the sensitive medium used. The simplest form of making an enlarged positive from a negative is by the use of bromide paper. If a large number of enlarged positives are required, however, it would be simpler to make an enlarged transparency from the negative, and from this make an enlarged negative by contact, and from which copies could be made in the usual way.

First, with regard to the light to be employed, as this is by no means an unimportant question. The negative from which an enlarged positive is to be made must be evenly and brilliantly illuminated.

Daylight enlarging is usually done with a solar camera (see under **Camera**), but a simpler contrivance can be made as follows:

All light from the window is blocked out, excepting a small space a little larger than the negative from which an enlarged positive is to be made. The negative is placed in the dark slide, and the two slides drawn out, and the black partition removed. The camera is fixed as close as possible to the hole, and outside the window is placed a mirror or a large white card at an angle of 45°, so as to reflect the light through the negative. At a distance from the lens is placed an easel or board to receive the sensitive paper or plate. No light enters the room except that which passes through the negative and lens to form the enlarged image. This method of daylight enlarging is, for some reasons, to be preferred, but the standard of illumination is not constant. With artificial light properly arranged good effects are obtained, and with this method it permits of the work being done in the evening or at night-time.

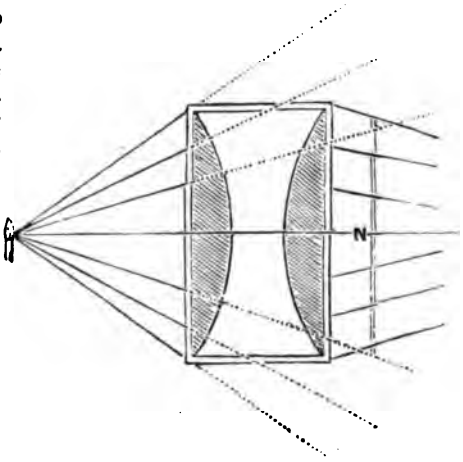


FIG. 177.

Of all artificial lights the electric is undoubtedly the best, but this is unfortunately beyond the reach of a great majority. Limelight is also very suitable, and now that compressed oxygen is obtainable anywhere its use is much simplified. Gas may also be used. The best arrangement is that known as the albo-carbon gaslight. In this the gas passes through paraffin wax, and its brilliancy is thereby considerably increased. Acetyline gas will also be used in the future as soon as a convenient method of using it is employed. Oil lamps can also be used.

The principal method of obtaining even illumination with artificial light is by means of condensers. This is, however, expensive, as an eight-inch condenser is the smallest that will do for a half-plate negative. The function of the condenser is to turn the diverging rays that impinge upon it into a bundle of converging rays, and the enlarging lens must be placed where it can best receive as much of the light as possible that passes through the condenser. The form of condenser usually employed is shown in Fig. 177. It consists of two plano-convex lenses mounted with the convex face inwards. It will be seen that but few of the rays would pass through the negative N were they allowed to proceed in the direction of their propagation, as shown by the dotted lines.

A condenser is not, however, absolutely necessary, provided a perfectly unifom surface can be produced. Ground glass, although often recommended, is but an imperfect diffuser; opal glass is superior. If this is placed halfway between the negative and four or six gas burners arranged in a group, a fairly even illuminant is obtained.

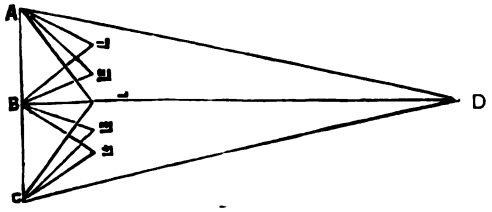


FIG. 178.

In order to better understand what even illumination means, we must take a glance at a book on elementary optics. In Fig. 178 we will suppose A B C to be a negative, L a source of light, the rays of which proceed from a point.

The lines L A L B will be the relative intensities, and it will be seen that by no means can even illumination be obtained. If the light be removed to D, although its intensity will be greatly diminished, even illumination will be secured. But to do this we must employ a very bright light, such as the electric one. Supposing, however, we substitute a much larger luminous surface by placing lights also at L_1, L_2, L_3 and L_4, it is easily seen that a much more even illumination is obtained. The distance from L to A or to C is not of any importance, as these parts are lighted up by L_1 and L_4. Another plan is to move the light, but this must be done in an equal direction, and with a perfect regularity of speed.

The lens used should be, if possible, the lens with which the negative was made. Failing this, a doublet or some other kind of lens must be used. If a single lens, the convex face must be turned towards the negative.

The lantern consists essentially of a box made to contain the light and the condensers. It should be capable of standing a great amount of heat, and should, as far as possible, be light-tight. The only light emerging from it must be through the negative. Fig. 179 is a sketch of an enlarging lantern.

Enlarging on Bromide Paper.—Bromide paper is the simplest to work with. There are several different kinds. With some, much better tones are obtained than with others. The paper is supplied ready sensitized in rolls, and can be obtained either with a smooth or rough surface. For large work the rough surface usually has the more artistic appearance.

A piece of white paper is attached to the movable screen, and upon this the image of the negative is sharply focused The lens is then capped with a piece of yellow paper or glass, and the piece of sensitive bromide paper fixed firmly into its place. A small stop may then be placed in the lens to give increased sharpness. Exposure is made by uncapping the lens, but the precise duration required is only found out by practice. It differs with every kind of negative, with the strength of the illuminant, and with the distance of the screen from the camera. With regard to the first two points no law can be given, but it is not a difficult matter to find out the relative exposures required for images placed at different distances from the camera as these are regulated by the following law: "*The intensity of illumination on a given surface is inversely as the square of its distance from the source of light.*"

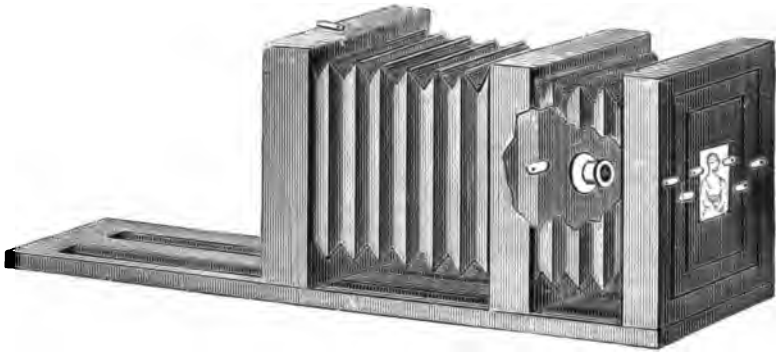


FIG. 179. ENLARGING CAMERA.

We see this more clearly in Fig. 180. Here a candle is the illuminant. Now suppose the bromide paper be placed at 1 (one foot away), and the exposure required was 30 seconds. If we remove it to 2, or two feet away from the candle, the exposure required would be four times as great, or two minutes, while at 3, or three feet from the illuminant, it would be nine times as long, or 4½ minutes, while at 4 it would require an exposure of eight minutes, or 16 times as long as at 1.

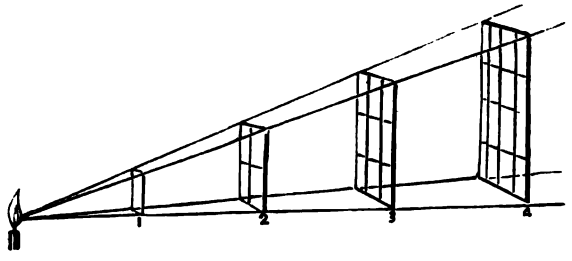


FIG. 180.

But even this useful law does not help us unless we know the correct exposure with a given negative at a given distance, and with a given illuminant. To prevent large pieces of the sensitive paper from being spoilt, it would be advisable to make the first attempts upon small pieces only until the correct exposure is ascertained.

The distance to place the screen from the camera lens to obtain the image the necessary number of times enlarged is easily found by reference to the tables given on page 135. It is necessary only to know the focal length of the lens, and turn to that column to obtain, first, the distance of the sensitive paper from the lens, and, secondly, the distance between the negative and the lens. Thus if the focal length of the lens be 9½ inches, we turn to the column headed 9½. On the left of the page will be found the number of times of enlargement or reduction, as the case may be. Supposing, for instance, we desire to enlarge four times linear (*i.e.*, sixteen times in area). We refer to ¼, and under column headed 9½ we find 3 feet 11½ inches and 11⅞ inches, the first being the distance of the screen from the centre of the lens, and the second number the distance of the negative from the len's centre.

The negative to be enlarged should be as sharp as possible, as any ill-defined parts have a very hazy and indistinct appearance in the enlarged image.

Vignetting can be done by putting a vignetting glass in front of the negative, or if an easel be used a suitable hole is made in a piece of carboard, and this is held in the hand and moved to and fro between the lens and easel during exposure, the rays of light passing only through the aperture in the cardboard.

Clouds may also be printed in. This is best done by cutting out in black paper the shape of the landscape portion of the picture, and this is pasted on to a piece of clean glass the same size of the negative. It is then placed on the lantern, together with a cloud negative, and the bromide paper is thus exposed for a few seconds only. It is then removed, and the landscape negative inserted and exposed. On developing, the landscape and clouds will appear simultaneously.

Development of the exposed bromide paper is usually done with the ferrous-oxalate developer, although pyro or other developers, may be used. The paper is laid on a large and shallow dish, and a little water poured over it. With a camel-hair brush all air-bells are removed. The water is then drained off, and some weak developer poured on. Make up three stock solutions, the first with a pound of potassium oxalate, dissolved in a quart of water ; the second, six ounces of granulated sulphate of iron and 50 grains of tartaric acid, dissolve in 16 ounces of water, and the third a ten per cent. solution of ammonium or potassium bromide. These solutions should be labelled 1, 2 and 3 respectively. For use, take eight parts of No.1 , and add

to it one part of No. 2 and half a minim of No. 3. It is advisable to first use a very weak developer until the image makes its appearance, when the operator should be able tell the best strength of the developer required. If a vigorous print be desired, a developer strong in iron should be used. Exposure should always be as full as possible; with an under-exposed print nothing can be done to get a really satisfactory image. Fuller particulars for working with bromide paper will be found under that heading. After development the pictures are well rinsed, and fixed in a one to six fixing bath. They are then well washed in several changes of water, and hung up to dry. When dry, they can be worked up with crayon or lamp-black.

Enlarging on Plain Paper.—Enlargements may be made upon plain paper in the following manner. A good quality of plain paper is salted with the solution—

Sodium chloride	200 grains
Hydrochloric acid	12 minims
Water	24 ounces

The paper is immersed for about a couple of hours, when it is hung up to dry. When dry it is floated for about three minutes upon a silver bath composed of

Silver nitrate	1 ounce
Citric acid	8 grains
Water (distilled)	8 ounces

As soon as moderately dry, the paper may be pinned on to the enlarging screen, and the image of the negative thrown on to it. A faint image only will be visible, but this is developed with

Pyrogallic acid	2 grains
Citric acid	1 grain
Water	1 ounce

As soon as developed it is well washed, and, if desired, it can be toned. The print is then fixed in

Sodium hyposulphite	1 ounce
Water	16 ounces

and should remain until all trace of color in the high-lights has disappeared.

Enlarging on Albumen Paper.—Enlargements may also be made upon albumenized paper. The paper should be sensitized on a bath composed as follows:

Silver nitrate	40 grains
Glacial acetic acid	30 minims – drops
Water	1 ounce

After exposure the paper is developed with

Gallic acid	3 grains
Acetic acid	5 minims
Water	1 ounce

The paper is immersed in this solution, and development will take place very rapidly. When sufficiently developed it is removed from the dish and well washed. It can then be toned and fixed.

Enlarging by Collodion Transfer Process.—Enlargement by the collodion transfer process is not employed now to the extent that it was formerly. The following is a *résumé* of the process. The collodion to be used may be any good negative collodion, which has been prepared for a few months at least, as the older it is the purer will be the image. This is diluted by the addition of from one-third to an equal part of a plain uniodized collodion. This addition is to insure a fine, soft gradation of tints, from the highest light to the deepest shadow. The following is a good formula:—To 25 ounces of a plain collodion, containing about seven to eight grains of pyroxyline per ounce, add a bromo-iodizer composed of

Cadmium iodide	65 grains
Ammonium iodide	25 grains
Cadmium bromide	19 grains
Ammonium bromide	11 grains
Alcohol	5 ounces

A small quantity of an alcoholic solution of iodine is then added to give a deep sherry color, but this is not necessary if the collodion be allowed to stand two or three months after mixing and before using. Glass plates, previously rubbed with French chalk, are coated with the collodion.

The silver bath should not exceed twenty grains to the ounce. With regard to the exposure, that, as in nearly every other case, can only be ascertained by experiment, but usually

varies in a solar camera between thirty to sixty seconds, according to the quality of the negative and the actinicity of the daylight. The developer is—

Pyrogallic acid	100 grains
Citric acid	60 grains
Acetic acid	2 ounces
Water	20 ounces

Development should not be carried too far. Fix with hypo-sulphite of soda. After fixing and washing, a sheet of transfer paper (previously soaked in cold water for a few minutes until it feels slightly slimy) is laid face downwards upon the collodion picture squeegeed thorougly into contact with it, and allowed to dry spontaneously. When dry it can be raised at one corner with a knife, and the whole stripped away from the glass, taking with it the collodion picture.

The picture has an exceedingly glossy appearance, and can be mounted on to cardboard, and, if desired, finished off in oil colors, without any preparation being required. If the collodion picture be stripped off before it is perfectly dry a duller surface is given.

The transfer paper used in this process is made by soaking four ounces of gelatine in a quart of water and dissolving it. Four grains of chrome alum are then added. Good stiff paper cut into sheets is then floated on the surface of the gelatine, which is kept warm by means of a water bath.

Enlarging on Canvas.—See **Printing.**

Enlarging by Dusting-on Process.—This is a process suitable for making enlargements on opal. A transparency is first made, as by this method a positive is produced from a positive. The plate is coated with the following solution:—

Dextrine	40 grains
White sugar	50 grains
Ammonium dichromate	20 grains
Glycerine	4 or 5 drops
Water	2 ounces

When dry it is exposed to the image of the transparency, after which powdered blacklead is brush over with a soft camel-hair brush. The fine powder adheres to those portions that have not been acted upon by the light. The plate is then coated with collodion, washed in dilute hydrochloric acid, and afterwards in water. It is then dried.

Carbon Enlargements.—This process is undoubtedly the finest one for the production of enlargements, as not only beautiful results are obtained, but these results are permanent, and will outlive all the silver pictures by many years. Carbon enlargements can be most successfully made in a solar camera, although the usual proceeding is to make an enlarged reversed negative, and from this to print the carbon positives by the single transfer process. (For details of the process see **Carbon Process.**)

The process of making enlarged negatives is very similar to that required for positives, except that a positive be placed in the lantern, and the image thrown upon a dry plate.

EOSIN.—There are two kinds of eosin, *i.e.* Tetra-bromo-fluoresceïn, potassium or yellow shade eosin. $C_{20}H_8Br_4O_5K_2$—M. w. 261 and tetra-bromo-fluoresceïn sodium or red shade eosin with a formula $C_{20}H_6Br_4O_5Na_2$.—M. w. 692. It is used in the orthochromatic process as a sensitizer to the yellow and green rays, soluble in water alchohol and benzine. See **Orthochromatic Process** and **Fluorescein.**

Commercial eosin is rarely found with a sufficient degree of purity for commercial purposes. The following method is given for its purification:* Dissolve 20 grammes of eosin in 700 c.c. of boiling water, and after dissolution add sulphuric acid 1:10 until no further precipitate of bromo-fluoresceïn is formed. The liquid is separated by decantation, and the salt washed and dried. The purified excess is insoluble in water but soluble in alcohol.

EPSOM SALTS.—See **Magnesic Sulphate.**

EQUATION, CHEMICAL.—A symbolic representation of a chemical reaction. (See **Chemistry.**)

EQUIVALENCY, CHEMICAL.—The quality in elements of combining with, or displacing one another in certain definite proportions. When the atomic weight is taken into consideration the equivalency of an element is termed its atomicity.

EQUIVALENT FOCUS.—See **Focus.**

ERYTHROSIN —An iodo derivative of Fluoresceïn (*q. v.*) The two kinds used in photography as dye sensitizers in the orthochromatic process are erythrosin M— tetra-bromo-fluores-

* "British Journal Almanac, 1894."

ceïn potassium or sodium. Formula, $C_{20}H_6I_4O_5K_2$ or Na_2.—M. w. 912, and Erythrosin G – Di iodo-fluoresceïn potassium or sodium. Formula, $C_{20}H_6I_2O_5K_2$ or Na_2.—M. w. 660.

ESSENTIAL OILS.—Oils, usually obtained from plants, which are volatile either alone or with steam. (See **Volatile Oils.**)

ETCHING.—(See **Photo-etching.**)

ETCHING SOLUTION.—A solution used in photo-zincographic and engraving processes. A solution for etching zinc is made up as follows:—

Nitric acid	1 drachm
Water	10 ounces

An etching solution for copperplate is:—

Solution of perchloride of iron	1 ounce
Water	6 ounces

ETHER.—(Formula, $C_4H_{10}O$; molecular weight=74; synonyms *ethylic oxide, ethylic ether, vinic ether* and *sulphuric ether*).—An exceedingly volatile, colorless liquid, prepared from alcohol by the action of sulphuric acid at an elevated temperature. Alcohol is first placed in a retort, and about an equal volume of sulphuric acid is added to it. This addition immediately develops heat, and by raising the temperature ether vapor passes away with a proportion of alcohol. A stream of alcohol is made to pass into the still, and the heat regulated at a temperature of about 266 deg. As soon as five volumes of alcohol have been added, the temperature is raised to 286 deg., at which point the impurities commence to pass over. Ether thus obtained contains sulphuric acid, alcohol and water. These are subsequently removed by heating with a calcium chloride solution.

The action that takes place in the manufacture of ether after this method is rather interesting—

$$\underset{\text{Sulphuric Acid.}}{H_2SO_4} + \underset{\text{Alcohol.}}{C_2H_5OH} = \underset{\text{Ethyl Sulphuric Acid.}}{C_2H_5HSO_4} + \underset{\text{Water.}}{H_2O}.$$

Thus the sulphuric acid acts on the alcohol, forming ethyl sulphuric acid and water. This acid is again acted upon by alcohol, producing the re-formation of sulphuric acid and ether, thus—

$$\underset{\text{Ethyl Sulphuric Acid.}}{C_2H_5HSO_4} + \underset{\text{Alcohol.}}{C_2H_5OH} = \underset{\text{Ether.}}{(C_2H_5)_2O} + \underset{\text{Sulphuric Acid.}}{H_2SO_4}.$$

The sulphuric acid is restored again, and can be used to attack more alcohol to form fresh ether. This action goes on until the acid becomes too weak, owing to the water in the first action diluting it.

Ether has a strong, sweet odor and a burning taste. Its vapor is very heavy, and highly inflammable. It has a specific gravity of about ·730 at a temperature of 60 deg. It boils at 96 deg, forming a heavy vapor two and half times as dense as air, and freezes at—24 deg. If a small portion be poured into the palm of the hand it will be found to vaporise so quickly that it will produce the most intense cold. It is so highly inflammable that it is not advisable to work with it in a room that has a naked light, unless with great care. If inhaled too freely it will also produce drowsiness and complete insensibility. If equal bulks of water and ether be added, and well shaken together the liquids will appear to separate, but the ether will have taken up about one-eighth of its volume of water, and the water has dissolved the same amount of ether. If it absorbs more it is fairly good proof of the presence of alcohol.

If pure ether be exposed to the light it ozonises and becomes acid, and in this state it is liable to decompose photographic substances placed in it. It is, therefore, advisable to keep it in a dark, and also a cool, place. The presence of water in ether is detected by dropping a little into a flask containing spirits of turpentine. If it be present it will cause instant turbidity, but otherwise it will unite perfectly. If ether contains much water it is gradually converted into alcohol and finally into acetic acid.

The employment of ether in photographic operations is very large, owing to its properties of dissolving iodine, bromine, sulphur, phosphorus, as well as of essential oils, corrosive sublimates, and other salts. It mixes with alcohol in all proportions, and is thus used in the manufacture of collodion.

The presence of oxidation products will cause the collodion to turn brown, owing to the liberation of iodine. This color can be removed and the collodion restored to its proper sensitiveness by shaking it up with metallic cadmium.

Methylated Ether is prepared in the same manner as above described, except that methylated spirit is used instead of alcohol.

If properly rectified and purified it answers very well for the manufacture of collodion, and is much cheaper than ethylic ether. Before using it, however, it should be quite free from methyl, and should not have become ozonized by exposure to light. Test for this in the manner given.

ETHYL ACETATE.—(Acetic ether, $C_4H_8O_2$).—Prepared by heating concentrated sulphuric acid to 130 deg., and then allowing a mixture of 60 parts of glacial acetic acid and 46 parts of 93 per cent. alcohol to run slowly into the flask. The ether distils over and is washed in a solution of soda, and then dried over calcium chloride. Ethyl acetate is a fragrant, colorless, limpid liquid. It is soluble in 17 parts of water; 28 parts of the ether dissolve in one part of water. It boils at 73 deg.

ETHYL ALCOHOL.—Obtained from acetic acid by converting the acid into acetyl chloride by distillation with phosphorus penta-chloride, and acting on a mixture of acetyl chloride and glacial acetic acid with sodium amalgam, which decomposes the acetic acid, liberating hydrogen, which acts on the acetyl chloride, converting it into aldehyde, which, by the further action of hydrogen, is converted into alcohol, and this is converted by acetyl chloride into acetic ether. This is then saponified by distilling with potash, yielding potassium acetate and ethyl alcohol.

ETHYL ETHER.—See **Ether.**

EURYSCOPE.—A name given to a kind of wide-angle lens.

EVAPORATE.—To transform into vapor. Liquids evaporate at temperatures below their boiling point. The rising vapor converts sensible into latent heat, with the effect of producing cold.

EVAPORATING DISH.—Dish for evaporating solutions. Enamelled "Agate" dishes, as shown in Fig. 181, serve their purpose well, as they are not acted upon by the vegetable acids.

EXCITING.—See **Sensitizing.**

EXPANSION.—All substances, whether gaseous, liquid or solid, when chemical change does not take place, expand more or less by heat, and contract by cold. This property should be carefully noted. Glass, for instance, expands very considerably by heat, and if the expansion be unequal it will crack. Any glass vessel into which hot water is to be poured should be previously warmed, unless the glass be very thin, when this precaution is not necessary.

FIG. 181.

Moisture will also cause expansion. This, with gelatine films, is often very annoying, as it causes them to leave the glass. The only remedy is to lay the plate in a strong solution of alum or alcohol.

EXPLOSIVE POWDER.—A powder used in the flast-light process of illuminating during exposure. (See **Flash-light.**)

EXPOSURE.—By exposure is meant the exposure to the action of light any sensitive surface, either in the camera to the image formed by the lens, or behind a negative in a printing frame. The exposure being the most important of all the photographic operations, it is lamentable that but little useful information can be given upon the subject. The proper knowledge of the length of the exposure is only attained by practical experience. With such sensitive substances as albumenized paper, or with any other printing-out process, the difficulty of exposure is reduced to a minimum, as the operator can see the image, and by attention stop the progress of the action of the light at the right moment required. With dry plates, however, or with any other process in which the image is invisible it is a very different matter The exposure of the dry plate is the most important point, as unless correctly exposed a satisfactory picture can rarely be made. The exposure of the plate is principally governed by the following:—(1) The subject to be photographed, its distance from the camera, and darkness of the shadow detail; (2) the rapidity of the lens, and its working aperture; (3) the actinicity of the daylight; and (4) the rapidity of the plate.

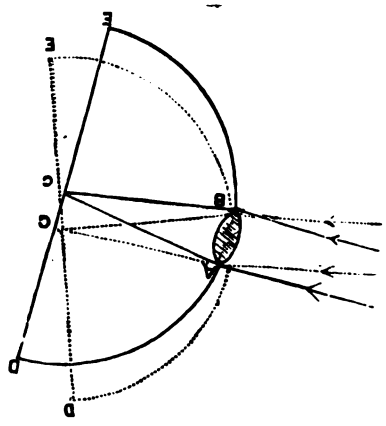


FIG. 182.

There have been many tables and arrangements invented for calculating the necessary exposure, but some of which are more likely to lead to confusion to the beginner than to aid him. The actinicity of the light varies so with the different days, or even times of the day, and some subjects require so much longer exposure than others, that this information can only be got by

practice. There is, however, a law relating to the comparative exposures required with different stops or diaphragms. The stops are usually marked with their fractional value, found by dividing the focal length of the lens by the diameter of their apertures. If all other conditions be precisely the same, the exposures required are proportional to the squares of the denominators of these fractions.

In exposing a plate, probably the best guide is the image upon the ground glass focusing screen. If the same kind of plate be always used, the operator, by examining the appearance of image, will soon be able to judge the correct exposure almost immediately. The following table might be useful as giving some idea of the proportional exposures necessary with a moderately quick plate and working with a lens aperture of $f/16$ with a good light.

Sea and sky	$\frac{1}{10}$ second
Animated scenes	$\frac{1}{4}$ second
Landscape, distant	$\frac{1}{2}$ second
Landscape, little foreground	1 second
Landscape, dark foliage foreground	2 seconds
Buildings	2 seconds
Interiors, well lighted	3 minutes
Interiors, badly lighted	45 minutes
Outdoor portraiture	5 seconds

The measurement of the light value is a very difficult proceeding, and cannot be accurately determined by exposing a piece of sensitive paper.

The rapidity of plates is also very confusing. Warnerke's sensitometer is usually employed, and plates are sold by manufacturers of various sensitometer numbers, as "30 times," "60 times," etc., intended to represent the number of times the plate is more sensitive than a wet collodion plate. But no reliance at all can be placed on these, some experiments proving nearly all to be incorrect, and some not possessing one-half the sensitiveness they were stated to have.

The following tables by Professor Burton and S. W. Very may also be fonnd of use in estimating comparative exposures:—

PROF. BURTON'S TABLE OF COMPARATIVE EXPOSURES.

Aperture calculated on the Standard System of the Photographic Society.	Sea and Sky.	Open Landscape.	Landscape with Heavy Foliage in Foreground.	Under Trees up to	Fairly lighted Interiors.	Badly lighted Interiors up to	Portraits in Bright Diffused Light out of Doors.	Portraits in Good Studio Light.	Portraits in Ordinary Room.
	SEC.	SEC.	SEC.	M. S.	M. S.	M. S.	SEC.	M. S.	M. S.
No. 1 or $\frac{f}{4}$	$\frac{1}{100}$	$\frac{1}{50}$	$\frac{1}{8}$	0 10	0 10	0 2	$\frac{1}{8}$	0 1	0 4
No. 2 or $\frac{f}{5.656}$	$\frac{1}{50}$	$\frac{1}{25}$	$\frac{1}{4}$	0 20	0 20	0 4	$\frac{1}{4}$	0 2	0 8
No. 4 or $\frac{f}{8}$	$\frac{1}{25}$	$\frac{1}{12}$	$\frac{1}{2}$	0 40	0 40	0 8	$\frac{1}{2}$	0 4	0 16
No. 8 or $\frac{f}{11.314}$	$\frac{1}{12}$	$\frac{1}{6}$		1 20	1 20	0 16	1$\frac{1}{2}$	0 8	0 32
No. 16 or $\frac{f}{16}$	$\frac{1}{10}$	$\frac{1}{3}$	2	2 40	2 40	0 32	2$\frac{1}{2}$	0 16	1 4
No. 32 or $\frac{f}{22.627}$	1	$\frac{2}{3}$	4	5 20	5 20	1 4	5$\frac{1}{2}$	0 32	2 8
No. 64 or $\frac{f}{32}$	$\frac{2}{3}$	1$\frac{1}{3}$	8	10 40	10 40	2 8	10$\frac{1}{2}$	1 4	2 8
No. 128 or $\frac{f}{45.225}$	$\frac{4}{3}$	2$\frac{2}{3}$	16	21 20	21 20	4 16	21	2 8	8 32
No. 256 or $\frac{f}{64}$	1$\frac{2}{3}$	5$\frac{1}{3}$	32	42 40	42 40	8 32	42	4 16	17 4

In the exposure of bromide paper it is usual to make a few experiments upon small pieces of paper. When once the correct exposure has been obtained it is possible to expose any number correctly, provided the same negative be used, placed at the same distance from the same light, and provided artificial light such as a gas flame be used.

In exposing platinotype or carbon paper, actinometers will considerably aid the operator in judging the exposure time.

DIAGRAM OF COMPARATIVE EXPOSURES.

Computed for the latitude of Washington, D. C. (38 deg., 54 min. N.)

By Lieut. Commander S. W. Very, U. S. N.

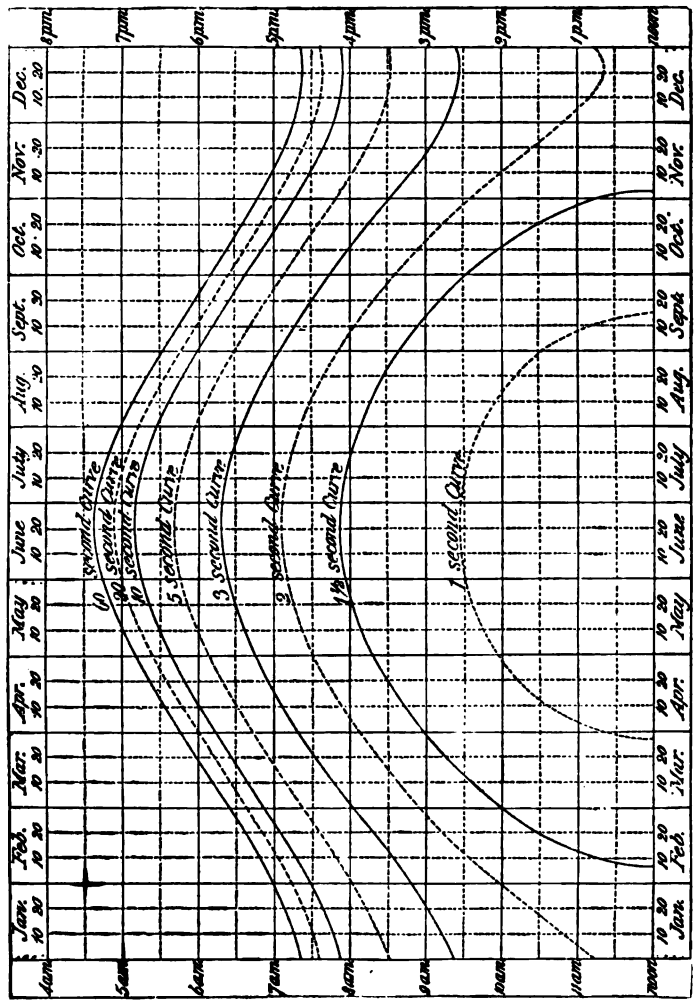


FIG. 183.

The straight lines in this diagram represent divisions of time; the vertical ones showing the month and day, and the horizontal ones the time of day as shown by a sun-dial.

The curved lines are curves of equal altitudes of the sun, computed for the latitude of Washington, for the year 1889.

The combination of the two systems of lines is designed to enable the photographer, whether amateur or professional, who has at some time determined the length of exposure required under certain circumstances of subject, clouds, lens, diaphragm, plate or film, etc., to decide what exposure to give *under the same circumstances*, at any time between sunrise and sunset, on any day of the year.

The diagram is based upon one constructed for the latitude of London, published in the *Photographic News*, in 1887, and reprinted in the Annual of 1888, and the same standard of comparison is used in this adaptation—that is, such circumstances of subject, clouds, lens, diaphragm, plate or film, etc., as will require an exposure of one second, at noon of any day between the 4th of April and the 7th of September, or at any time between a quarter to ten in the forenoon and a quarter past two in the afternoon on the 21st of June.

The diagram, although constructed for the year 1889, and for the latitude of Washington, will serve equally well for any other year, and well enough for ordinary purposes, throughout the United States (exclusive of Alaska), although in the extreme Northern and Southern belts it will not be accurate.

The diagram is strictly accurate for "apparent time" only, but it is sufficiently so for "local mean time" (which may differ sixteen minutes from "apparent time"), and in the great majority of places for "standard time" (which in some places differs half an hour from "mean time," and may differ three-quarters of an hour from "apparent time)."

EXAMPLES.

Q. With a certain lens, diaphragm, etc., it is found that on the 20th of July, at 9.30 A.M., a certain subject requires three seconds' exposure; what time should be given on the 10th of December, at 3:30 P.M., the subject, lens, etc., being the same.

A. Fifteen seconds.

Q. At noon of the 15th of May, a certain subject required ten seconds; what length of exposure should be given to the same subject, with the same lens, diaphragm, etc., on the 1st of November, at 8 A M.?

A. Forty-five seconds.

TABLE OF COMPARATIVE LIGHT VALUES.

By Rev. Dwight W. Smith.

While there is a wider range in timing the exposure of a dry plate than is generally supposed, yet it is well known that there is but one correct interval for the best results with a normal developer. To best approximate that interval at all available hours of the day and year requires some attention and experience. There was a time when plates of a given brand and sensitiveness were quite unreliable, but now that they are so uniform, and improving more and more in this direction, tables of light values that were found to be comparatively useless will

now be found of increasing value. The subjoined table, based upon the diagram in this book, by Lieutenant S. W. Very, U. S. N., has been computed for the first half of each month, and at a glance one may obtain information that would otherwise require time and trouble, and that even skill and experience does not always provide for, especially during the time indicated in which there is a rapid loss of light. It will be seen that in January, the light value for noon is given as 1.7, while at 4 P.M., the exposure would necessarily be more than five times that duration. For July, the most rapid as well as longest available light of any month, the light at noon is indicated by .2 instead of 1.7, and at 3 P M. more than twice the time will be required.

The first column indicates the hour of the day; the second column the comparative light values in whole numbers and tenths.

JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
8	10	8	6	8	3	8	2	8	1 7	8	1.7
9	4	9	4	9	2	9	1.5	9	1.2	9	1.2
10	2.5	10	2	10	1.5	10	1.7	10	1	10	1
11	2	11	1.7	11	1.2	11	1	11	.7	11	.6
12	1.7	12	1.5	12	1	12	1	12	.5	12	.3
1	1.7	1	2	1	1	1	1	1	.7	1	.5
2	2.5	2	2.7	2	1.7	2	1.2	2	1	2	.7
3	4.5	3	3.5	3	2	3	1.5	3	1.2	3	1.2
4	9.5	4	5	4	4	4	2	4	1.5	4	1.5
		5	60	5	20	5	4	5	2.7	5	2.2
						6	20	6	15	6	5
								7	80	7	20

JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
8	1.5	8	1.7	8	2	8	3	8	4	8	9
9	1.2	9	1.5	9	1.5	9	1.7	9	3	9	3
10	1	10	1	10	1	10	1.5	10	2	10	2
11	.5	11	.7	11	1	11	1.2	11	1.7	11	1.5
12	.2	12	.5	12	.5	12	1	12	1.5	12	1.7
1	.5	1	.5	1	1	1	1.2	1	1.5	1	2
2	1	2	1	2	1.2	2	1.5	2	2	2	2.5
3	1.2	3	1.2	3	1.5	3	2	3	2.5	3	3.5
4	1.5	4	1.7	4	2	4	2.7	4	5	4	8
5	2.2	5	2.5	5	3	5	6	5	20	5	80
6	4	6	5	6	10	6	40	6	70		
7	15	7	60								

FABRIC.—Photographic fabric is a name generally given to a translucent cloth dyed of a golden yellow or red color, and used for dark room windows. It is always advisable to use two thicknesses, as there are usually a number of fine holes, almost invisible, but which, at the same time, allow of the entrance of white light.

FADING.—A sad defect to which negatives and prints (particularly silver prints) are liable.

The cause of negatives fading is usually insufficient fixing with the sodium hyposulphite, or the incomplete removal of the hyposulphite from the film after fixing. The remedies are obvious.

The fading of silver prints has long occupied the attention of scientists who, apparently, have not yet arrived at any really satisfactory conclusion.

The most important causes of unmounted photographs fading are probably—First, the imperfect coagulation of the albumen and the presence of some organic matter liable to rapid decomposition liberating sulphurous gases, which attack the silver. Sulphur is the most dangerous substance to be present in the print. Albumen, unfortunately, contains minute quantities of it, which probably give rise to some compound of silver and sulphur. This is, perhaps, why prints upon gelatino-chloride papers are so much more permanent than upon albumenized paper, although the ingredients are almost precisely the same, except that the silver salts are held in gelatine instead of albumen. A second cause of the fading of prints may be in the insufficient deposit of gold in the toning process. Prof. W. K. Burton recently pointed out that the less gold a sample of paper required to tone it, the less likely would be that paper to produce permanent prints, and it should therefore be rejected. A third cause of fading is the trace of organic salts of silver remaining in the film as a compound of albumen and the metal. The presence of this causes the print to decay slowly. Its action can be arrested by treating the prints with bichloride of mercury, a very powerful antiseptic and coagulator of albumen. Yet another cause of faded prints is in the insufficient fixing or removal of the sodium hyposulphite from the paper prints. It is not an easy matter to tell exactly when prints are fixed, and there is no doubt whatever that many make the mistake of removing them too soon from the bath.

In the removal of the hypo from the prints a great deal of the probable permanency depends. The washing of the prints should be rapid and thorough. If a print be laid a few minutes in clean cold water, kept moving about and then removed, the water allowed to drain off and the print placed in a fresh supply of cold water, and this operation repeated, say, ten or twelve times, the print will in one hour have received a more thorough freeing from hypo than it would have done had it been placed in a running stream of water for 24 hours.

There are a number of solutions for removing the fixing salts (see **Eliminator**), but none is to be recommended. Water, changed frequently, is the best eliminator.

With regard to mounted photographs, fading can very often be traced to the mount or to the mounting solution employed. In the manufacture of mounts hyposulphite of soda is often used as an anti-chlor. This should be tested for, and the mounts containing it discarded. The mountant should be as pure and as simple as possible.

FAHRENHEIT THERMOMETER.—A thermometer introduced by Fahrenheit in 1714, and still largely used in England. In this scale the freezing point of water is + 32 degs., and the boiling point of water + 212 degs., leaving 180 degs., between them. In the centigrade thermometer used on the Continent the space is divided into 100 degs., freezing point being 9 degs., and boiling point 100 degs. To reduce Fahrenheit degrees to centigrade, subtract 32, multiply by 5, and divide by 9.

FALLING FRONT.—See **Rising Front.**

FALSE DISPERSION.—See **Dispersion.**

FALSE PERSPECTIVE.—See **Perspective.**

FERRIC AMMONIUM CITRATE.—Formula, $Fe_2 (NH_4)_2 (C_6 H_5 O_7)_3$. (Synonym *ammonia citrate of iron*). Occurs in thin, nearly transparent, brownish scales, and should be kept in the dark as light oxidises them. It is soluble in water and alcohol. To manufacture it Leaper gives the following instructions: Mix in a 30 ounce flask 4 drachms of strong sulphuric acid with 7 ounces of water, and having raised the liquid to boiling, dissolve 6 ounces of ferrous sulphate in it. Now add half an ounce of strong nitric acid, diluted with 2 ounces of water, to the mixture, and continue boiling until the iron is completely oxidized, as is evidenced by its ceasing to give a blue precipitate with potassium ferricyanide. Next precipitate the iron completely with an excess of ammonia, well wash the precipitate and boil it for five minutes with 4 ounces of citric acid dissolved in 10 ounces of water. Filter the mixture and when cool add to it 3½ ounces of ammonia s. g. .96. Filter again, evaporate to dryness at 100 degs. C., and keep the residue in a stoppered bottle.

On exposure to light ferric ammonium citrate in contact with the organic nature of the paper on which it is spread becomes converted into a ferrous salt. This property is made use of in the "blue" process. See **Cyanotype.**

FERRIC AMMONIUM OXALATE (Formula $Fe_2 (NH_4)_2(C_2 O_4)_4$. Synonyms, *ammonia oxalate of iron*).—Occurs in green very soluble crystals which should be kept in the dark as when exposed to light they become more or less oxidized, which fact is made use of in the "blue" or cyanotype and the platinotype processes. It can be prepared by dissolving 3 ounces of oxalic acid in 8 ounces of water, raise to 212 degrees fahr., and saturated with moist ferric hydrate, avoiding excess. Filter the solution thus obtained and neutralize with ammonia, filter and evaporate to dryness at 100 degs. C.

FERRIC CHLORIDE (Formula, Fe_2Cl_6. Synonym, *Perchloride of Iron*)—Usually purchased in solutions of a reddish-brown color. If it contains free hydrochloric acid its color will be somewhat lighter. Employed in reducing negatives.

FERRIC OXALATE.—(Formula, $Fe_2(C_2O_4)_3$. Synonym, *sesquioxalate of iron*).—Commercial ferric oxalate is usually a solution of the salt in oxalic acid. It can be prepared by adding ammonia to a hot dilute solution of ferric chloride. The precipitated hydrate of iron is then thoroughly washed and drained. Finely powdered oxalic acid is then added in small quantities to the gelatinous mass, vigorously shaking. After a few hours the whole will then be dissolved, and the solution is filtered. As soon as the oxalic acid is added the whole must be protected from the light.

Ferric oxalate is sparingly soluble in water, but freely so in presence of oxalic acid or of potassium or sodium oxalates. Ferric oxalate on exposure to light is converted into ferrous oxalate and on this account is used in the platinotype and certain blue printing processes. Mixed with hypo it is used as a reducer for negative prints, as in contact with silver it is converted into ferrous oxalate, silver oxalate being formed at the same time, which the hypo dissolves.

FERRIC SULPHATE (Formula, $Fe_2(SO_4)_3$. Synonyms, *persulphate of iron, sesquisulphate of iron*).—Obtained by oxidizing ferrous sulphate with nitric acid, and adding sulphuric acid. It is a yellowish-brown deliquescent mass, readily soluble in water, but insoluble in alcohol. It has a slightly solvent action upon metallic silver and it is for this reason employed to clear slightly veiled negatives.

FERRICYANIDE OF POTASSIUM.—See **Potassium Ferricyanide.**

FERROCYANIDE OF POTASSIUM.—See **Potassium Ferrocyanide.**

FERROCYANIDES, TESTS FOR.—Soluble ferrocyanides give, with ferric chloride, a dark blue precipitate, with silver nitrate a really white precipitate and with copper sulphate a brownish red precipitate.

Ferricyanides give with nitrate of silver a dark orange precipitate and with copper sulphate a greenish-yellow one.

FERRO-GELATINE DEVELOPER.—A name given by Carey Lea to one of his old, now unused, collodion developers.

FERRO-PRUSSIATE PROCESS.—See **Cyanotype.**

FERROTYPE.—A name given by Hunt to a process in which collodion positives were made upon thin plates of black or chocolate enamelled iron instead of glass. The results are called "ferrotypes" or "tintypes." Itinerant photographers still employ this method of producing positives direct in the camera, as they are able to supply their customer with the finished print in a few minutes. The process is the same as that employed in the manufacture of collodion positives (*q.v.*), save that the metal plates are used in the place of glass.

FERROTYPE PLATE.—A thin sheet of iron, coated over with a black or chocolate enamel, and used for making positives on, in the ferrotype process.

Ferrotype plates can also be used instead of glass in surfacing or enamelling gelatine prints. See **Enamelling.**

FERROUS AMMONIUM SULPHATE (Formula, $FeSO_4(NH_4)_2SO_4CH_2O$. Synonym, *double salt of iron and ammonium*).—Prepared by mixing two parts of ferrous sulphate with one part of ammonium sulphate and dissolving in twice the weight of boiling water previously acidified with a little sulphuric acid. When cool, pale blue-green crystals of the double salt will crystallize out. It is used in place of ferrous sulphate by many on account of its superior stability.

FERROUS CITRO-OXALATE DEVELOPER.—A developer for dry plates introduced by Abney. It is made as follows:

Potassium citrate (neutral)	100 grains
Ferrous oxalate	22 grains
Water	1 ounce

The potassium citrate is first dissolved in a flask by heat, and when nearly boiling the ferrous oxalate is added and shaken up in it, a cork being used to prevent the access of air to it. This amount of ferrous oxalate should just dissolve. It is cooled by allowing cold water to flow over it, and should then have a citrony red color.

FERROUS NITRATE (Formula, $Fe(NO_3)_2$. Synonym, *nitrate of iron*) occurs in brown greenish deliquescent crystals. It is sometimes used in collodion positive ferrotype, or other processes where the positive is viewed by reflection, on account of the white color of the silver deposit.

FERROUS OXALATE (Formula, FeC_2O_4).—A yellow powder obtained by dissolving 2 ounces of ferrous sulphate in 15 ounces of water, acidified with sulphuric acid, and the solution mixed with 396 grains of oxalic acid dissolved in 15 ounces of water. In four or five hours the precipitate of ferrous oxalate will be complete. The liquid is decanted off and the precipitate washed and dried. Ferrous oxalate is practically insoluble in water, but will dissolve to a certain extent in solutions of alkaline oxalates, such as the oxalates of potassium, sodium and ammonium. Oxalate of potassium is the one generally preferred and used in the ferrous oxalate developer, because a saturated solution of it dissolves more of the ferrous salts than any of the other oxalates.

FERROUS OXALATE DEVELOPER.—See under **Developer.**

FERROUS OXALATE INTENSIFIER.—See **Intensfier.**

FERROUS SODIUM OXALATE (Formula, $Fe_2Na_2(C_2O_4)_4$. Synonym, *sodium ferric oxalate*). Prepared in the same manner as ferric ammonium oxalate, except that sodium hydroxide is used to neutralize the oxalic acid. It is used in the printing-out platinotype process.

FERROUS SULPHATE (Formula, $FeSO_4, 7H_2O$. Molecular weight, 278. Synonyms, *green vitriol* or *copperas*, *protosulphate of iron*).—Obtained by acting on iron wire or filings with dilute sulphuric acid, evaporating and crystallizing. Pure ferrous sulphate forms bright green crystals. If kept in a perfectly-stoppered bottle it is remarkably permanent. In dry air they effloresce, and in damp air become coated with a brown coating of ferric-sulphate.

Ferrous sulphate is insoluble in alcohol, but soluble in twice its weight of water. In solution it rapidly becomes oxidized, and rendered useless by exposure to the air. If a small crystal of an acid, such as citric or tartaric, be added, it will prevent the fall of the precipitate,

though not the oxidation. A solution that has turned quite yellow can be revived by placing in it a small quantity of citric acid and a few pieces of zinc.

Ferrous sulphate is used in the ferrous oxalate developer; it forms double salts with the alkaline sulphates. The double sulphate of iron and ammonium gives a more permanent solution than ferrous sulphate, and is, for this reason, preferred by many as a developer for wet collodion plates.

The rapid deterioration of the ferrous oxalate solution can be avoided if the latter be placed in a bottle. A film of oil rests upon the solution, and entirely protects it from the air. The two tubes are arranged so that the developer may be drawn off without disturbance. By blowing down the tube pointing upwards, the pure developer will be forced out of the opposite tube into the vessel ready to receive it.

FIELD OF THE LENS.—The illuminated space on a screen made by any lens working with full aperture.

FIGURES IN LANDSCAPES.—Nothing adds more to the beauty of a landscape than the introduction of well-selected and properly posed figures. Nothing goes farther to mar the beauty of a landscape than the introduction of badly selected or inartistically posed pictures. Robinson, in his *Pictorial Effect in Photography*, says: "Before placing figures in a landscape the artist should first make up his mind whether the composition requires the introduction of any subject to add to its completeness. If he considers it does, do not let anything induce him to take the view without the figure, because he will be doing something which he can see could be done better with the assistance of a little more trouble; above all he should avoid incongruity, and never, for the sake of pleasing a friend by putting him in the picture, introduce an element of discord. The figures should look so right where they are placed that we should have no suspicion that it would be possible to place them anywhere else. . . . The figures and the landscape should never be quite equal in interest or pictorial value. The one should be subordinate to the other. The pictures should consist of figures with a landscape background (if they are represented in the open air), or of a landscape in which figures are introduced merely for the sake of impressing a point, or adding life to the more important scene."

FILIGRANE.—See **Photo-filigrane.**

FILM.—A thin skin or pellicle of gelatine, collodion, etc., on plates or paper. A film of gelatine or collodion is given to a glass by pouring one of these substances on when in a liquid state, and allowing it to dry. To remove the gelatine films from glass they should be laid in a weak solution of hydrofluoric acid, or they can be removed by rubbing with a paste formed with pumice-stone powder and acetic acid. In order to remove the superfluous film found on the backs of dry plates, they shoud be allowed to dry, and the portions of films removed with a little salt applied with a moistened rag.

FILM NEGATIVE PROCESS, or film photography, is a term applied to processes in which flexible films are used instead of glass plates. As far back as 1855 Scott Archer patented a method of coating collodion negatives with a solution of gutta-percha in benzole. When dry the film was separated from the glass by soaking in water. The glass might also be made to receive a preliminary coating of gutta-percha, the effect of which would be to enclose the collodion film between two waterproof films. The late W. B. Woodbury used during the collodion days a method by which glass was superseded in part. A sheet of glass was first rubbed over with powdered talc, and then coated with a collodion emulsion. After exposure these plates were developed, fixed, and washed, and a sheet of gelatine paper was squeegeed to the finished negative. When dry, the whole could be peeled off the glass, which was again used.

The recent advances in film photography consist in the coating of paper, insoluble gelatine, celluloid, or other flexible material with the sensitive bromide gelatine emulsion. These films are then exposed in the camera, developed, and fixed in the same manner as dry plates. Their principal advantage over glass is, of course, in their lightness, and they have been largely used by tourists and travellers. They have also the advantage of being flexible, unbreakable, and can be packed in a very small space. In the photography of brightly lit objects they are superior to glass, as halation is avoided. Another advantage is that prints can be made from either side with equal facility—a great advantage to the carbon or collotype printer.

The best kind of films are those made upon insoluble gelatine or celluloid. To make the former, clean a large sheet of glass and rub it well with French chalk. A thick solution of gelatine is then poured over it, and the plate placed on a levelling stand to set. When dry the plate is placed in a saturated solultion of chrome alum. This effectually renders the gelatine insoluble. It is then washed, dried, and removed to the dark room to receive the dry-plate emulsion in the manner described under dry-plate. When dry the film is stripped from the glass, and cut up to the required sizes. Instead of chrome alum, the gelatine film may be hardened by soaking with potassium dicromate, exposing to the light, and then well washing; but I believe this method is covered with a patent.

Sensitive films are now made in lengths, and can be used in suitable holders, so that a roll of, say, 25 exposures can be obtained without changing. (See also under **Paper Negative, Stripping Films.**)

FILMOGRAPH.—A name given by Humphrey to a camera adapted for the use of films. (See also **Roll-holders.**)

FILTER.—An arrangement through which a liquid is passed to arrest matters mechanically suspended therein. An ordinary filter is made by twisting a piece of filtering paper into proper shape in a funnel. Collodion is usually filtered through tufts of cotton-wool. Gelatine emulsion is filtered through chamois leather, being forced through by pressure. A very simple method of filtering aqueous liquids, which do not deteriorate when exposed to the air, is by drawing them off from one vessel to another by means of a few threads of loosely twisted cotton or worsted arranged to form a syphon. The little twist of cotton at once performs the operations of decantation and filtration. This method will very often be found convenient when it is required to draw water off from a precipitate.

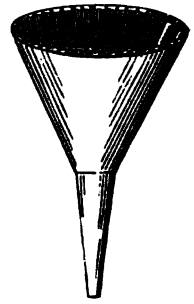


FIG. 184. — FILTERING PAPER ARRANGED IN FUNNEL.

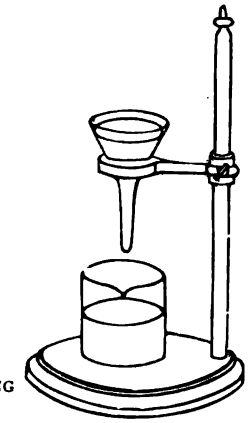


FIG. 185.—FILTER-STAND

FILTERING PAPER.—A bibulous, unsized paper, thick and woolly in texture, and used for filtering solutions. Swedish filtering paper is thinner, but of superior quality. It is usually cut in round discs. Before placing in the funnel these should be folded several times so that the sides are a number of creases. This will allow of the solution filtering through the sides of the paper, and not at the bottom of the cone only. Good filtering paper should not contain any soluble matter, and when burnt should not give more than $\frac{1}{150}$ to $\frac{1}{100}$ of its weight in ashes. Any soluble matter in the paper can be removed by washing it in hydrochloric acid and afterwards in distilled water.

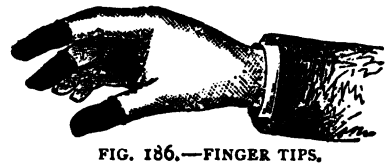


FIG. 186.—FINGER TIPS.

FILTRATE.—Any liquid which has passed through a filter.

FINDER. —See **View Meter.**

FINGER TIPS.—India rubber finger tips are extremely useful little articles, and should always be used when working with acids, process or silver solutions. (See fig. 186).

FIXING.—A term applied to the dissolving away of the sensitive salt unacted upon by light. In the collodion process, potassium cyanide is used as the agent, but in the dry-plate process it is not to be preferred for three reasons—first because it dissolves to a slight extend the finely divided silver that constitutes the image; secondly it has a strong alkaline and softening effect upon the gelatine; and thirdly, it is a most powerful poison.

Sodium thiosulphate, or, as it is more commonly known, sodium hyposulphite, is usually employed. It possesses none of the disadvantages of the potassium cyanide. Its action is to first change the silver bromide into silver hyposulphite, thus :—

$$2AgBr + Na_2S_2O_3 = Ag_2S_2O_3 + 2NaBr$$

and a further quantity of the salt combines with this silver hyposulphite formed to produce a double salt. There are thus two double hyposulphites of silver and sodium, the first $Ag_2S_2O_3Na_2S_2O_3$ is practically insoluble in water, but the second $Ag_2S_2O_32Na_2S_2O_3$ is exceedingly soluble. It is for this reason that it is necessary to have a large excess of the sodium salt.

The fixing bath is usually made up by dissolving four or five ounces of hyposulphite in a pint of water. It should be made a day or so previous to using. It will keep for a great length of time, but is liable to become acid. In this case it should be tested, and if required, restored with a few drops of ammonia.

On the introduction of the developed negative in the fixing bath the action of the latter can be easily seen as it dissolves the silver compound. After a few minutes if the back of the negative be examined, it will be observed to have a mottled appearance, or to possess white patches. These are portions of the film where the hypo has not yet done its work. On returning to the solution these parts will eventually disappear. The plate should be allowed to remain a few minutes longer, and then removed.

The addition of alum to the fixing bath is often recommended for simultaneously hardening the negatives and preventing blisters. It is not advisable, however, to mix anything with the hyposulphite bath. Alums and acids decompose it rapidly with precipitation of sulphur and liberation of sulphurous anhydride. If an alum bath is to be used, it should be after fixing and washing.

The strength of the fixing bath for silver prints is about the same as that already given. The prints after toning and washing are laid in it for from ten to fifteen minutes. The action is quicker than with negative films, as the bath can attack both sides at one time. Care should be taken that the prints are not removed before they are thoroughly fixed, otherwise they will rapidly fade.

The difficulty of removing the hypo-sulphite from films and paper prints is the chief drawback to its use. It can only be done satisfactorily by repeatedly washing in many changes of water.

Other fixing agents have been introduced from time to time. Some years ago the sulpho-cyanides were proposed; careful trial, however, proved them to be inferior. Dr. Liesegang recommended magnesium chloride, it being an easily obtainable and harmless salt.

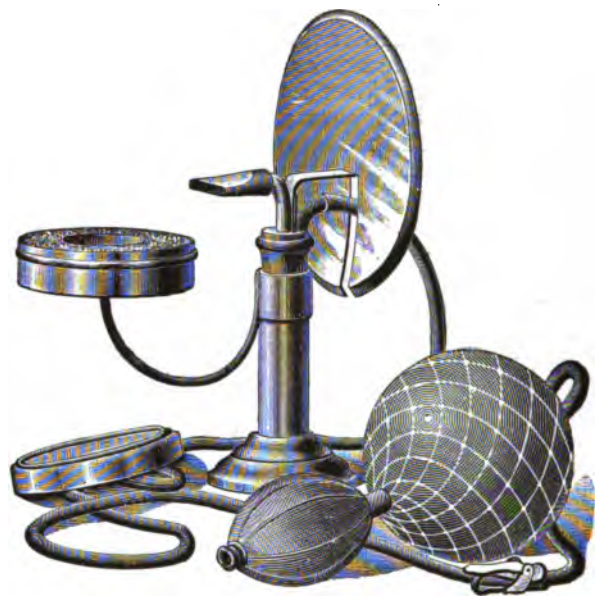


FIG. 187.—FLASHLIGHT APPARATUS.

FLARE.—A defect in a lens, when the image of the aperture of the diaphragm or of the lens itself shows as a circular patch of light on the focusing screen, and in the developed plate as a fogged patch in the centre of the negative. Although this is usually considered to be an image of the diaphragm or lens aperture, Monckhoven, in his work on "Photographic Optics," considers that it is due to the too close adherence to the globular form in the construction of the lens.

If this defect makes its appearance, the diaphragm apertures should be painted with a dead black varnish, as it is sometimes due to the edges having been worn bright. The Iris diaphragm is particularly liable to this defect by reason of the friction of the tongues of metal forming the apertures.

FLASHLIGHT.—Usually made by blowing magnesium powder through a small flame. This produces a flash of bright light sufficiently actinic for the purpose of making portraits or groups. In the purchase of the magnesium powder care should be taken that it does not contain a large portion of zinc, as many of the cheaper kinds do. It should be carefully stored in tightly-fitting tins or stoppered bottles, otherwise it will be rendered useless by absorbing moisture from the air. There has been recently a number of different patents and inventions for flashlight apparatus. All that is really required is an arrangement similiar to that depicted in figs. 187 and 188, by which a spray of the magnesium or flash powder can be ejected through a gas flame, and if the gas bracket be fitted with universal joints it will be possible to throw the light from any desired angle. If improperly managed, flash-light photographs present a very ghastly black and white appearance. We have to remember that the conditions under which we are working with flashlights are very different from those made by daylight. In the latter the light is diffused throughout the room, while with the flash lamp it is concentrated to what may almost be termed a point. The effect of this is not difficult to imagine—high lights and dark shadows and absence of detail in both. All defects in the skin are magnified a hundredfold, the slightest personal defect being exaggerated to an unpleasant degree. To avoid this it will be necessary for the artist to carefully study the position of the light, and the distribution of it over the sitter by reflecting screens and contrivances. If properly and judiciously managed, this power to concentrate, diffuse and distribute the light at will is one of the chief advantages, and, if carefully carried out, some very striking effects may be produced.

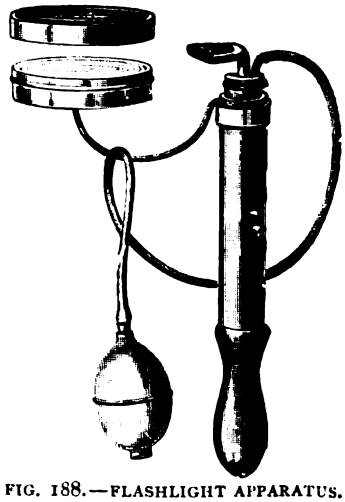


FIG. 188.—FLASHLIGHT APPARATUS.

Besides the production of portraits at night time, the flashlight has been put to other very useful purposes. For making photographs of interiors its utility cannot be over estimated. In science it has been used for photographing the interior of tunnels, coal mines, caves, etc. The oculist has found it useful in photographing the retina of the eye. When in perfect darkness the pupil of the eye is dilated to its utmost, and a flashlight photograph can be made of it so rapidly that it has no time to contract, and so an image is made of it as it cannot possibly be seen by the eye. In developing flashlight negatives use as little pyro or eikonogen as possible, so that the detail will have time to appear. When this occurs apply the full strength of the developer.

FLASHLIGHT POWDER.—A powder usually made with powdered magnesium, chlorate of potash, picric acid, and potassium dichromate, and used in flashlight photography. The manufacture and use of these powders is not unattended by extreme danger, many accidents and loss of life have already taken place. For all ordinary purposes the pure magnesium powder may be used. The addition of a small quantity of ammonio-chlorate of copper will give a blue flashlight.

FIG. 189—FLASK.

FLASK.—A glass vessel for holding liquids. It is usually made of iron-glass so that heat can be applied without fear of breakage.

FLATNESS.—A term used in photography to denote a lack of vigor or contrast in the negative or in the positive. The effect is usually due to over-exposure, or to over-development.

FLATNESS OF FIELD.—A lens is said to give great or less flatness of field, according to its power of defining objects in the centre and at the margin of the image. The image formed by a double convex lens is, as will be seen on reference to Fig. 190, of a concave form. The retina of the eye, upon which the image is thrown, is of a concave form, hence we see all things straight. In the camera, however, we employ a plane screen. The effect of this is that if we focus the centre of the image on the ground glass, the sharpness of the outer portions is destroyed, and if we bring the latter into focus the centre becomes indistinct.

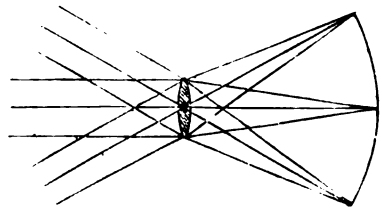


FIG. 190

In making compound lenses the principal object aimed at is to bring the light rays as near as possible to a focus on a plane. Theoretically this is impossible, but opticians have made very wonderful strides of late years in this direction, and many lenses are now made possessing great flatness of field.

FLEXIBLE SUPPORT.—An improvement in the carbon process, patented by J. R. R. Sawyer in 1874. See **Carbon Process.**

FLINT GLASS.—A species of glass usually composed of white sand, potassium carbonate, lead oxide, alumina, with metallic addition to neutralize the color. The flint glass of Guinand (one of the first optical glass makers) is composed of

White silicious sand,...	37·5
Red oxide of lead	37·5
Potash (best)	8·5
Borax	·15
Nitre	·18
Manganese	·17
Arsenious acids	16
Waste pieces of previous meltings	100

The silica for the manufacture of flint glass was formerly manufactured from pulverized flints, hence the name.

Flint glass is largely used in the manufacture of photographic lenses. See **Glass.**

FLOUR PASTE.—See **Mountant.**

FLUID LENS.—A lens containing water was patented by Thos. Sutton in 1859. The patent rights were afterwards bought by Ross, and since then other fluid lenses have been constructed. Sutton's lens was an achromatic panoramic (see Fig. 191), with which, owing to its spherical form, the oblique rays were transmitted almost as perfectly as the central ones.

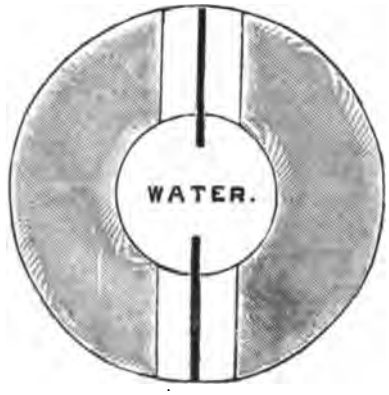


FIG. 191.

Fluid lenses have never become popular, owing to the chance of leakage, and also to the impossibility of keeping the temperature of the liquid perfectly equal, which was necessary, as a change in the temperature means also a change in the refractive power of the lens.

FLUORESCËIN (Formula, $C_6H_4[COC_6H_3(OH)_2]_2$).—A yellowish-red powder freely soluble in alcohol, slightly in water, giving a green fluorescent solution. The bromo and iodo derivatives—eosin and erythrosin—are employed in the orthochromatic process.

FLUORESCENCE.—In optics, a quality which exists in rays of light by which, under certain circumstances, they undergo a change of refrangibility. Certain solutions. if viewed by transmitted light, are colorless, but become of a bluish tint if viewed by reflected light.

FLUORHYDRIC ACID.—See **Hydrofluoric Acid.**

FLUORINE (Symbol, F; atomic weight, 191).—A non-metallic element, only recently obtained in a free state. It is an isometric, transparent mineral usually obtained from fluor spar.

FOCAL LENGTH.—See **Focus.**

FOCIMETER.—An instrument used in testing for chemical focus. (See Fig. 105).

FOCUS.—A term used in optics.

Principal Focus.—If a pencil of parallel rays enter a convergent lens, they will be brought together at a point F (Fig. 192) on the other side of the lens. This point is termed the *principal focal point*, and its distance from the lens is termed the *focal length*. Those rays which pursue a parallel course before they enter the lens are condensed to a point nearer the lens than diverging rays. The rays of light proceeding from very distant objects are parallel, while those from near objects diverge. When the rays diverge from a point, that point is associated with the focus, and the two are termed conjugate foci. The distance between the lens and the object is the anterior or major conjugate, and that existing between the lens and the ground glass the posterior or minor conjugate focus. In Fig. 193 F is the principal focus, and A and B are the conjugate foci. If an object be placed at A it will have its focus at B, and conversely if placed at B, its focus will be at A. It will therefore be seen that the principal focus of the lens never varies, but the length of focus for objects near at hand becomes greater the nearer they are brought to the lens. The relation of the conjugate foci is governed by certain laws. On page 135 will be found a table of conjugate foci, which should be carefully studied.

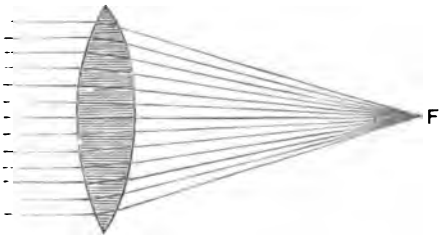


FIG. 192.

In dispersing lenses the focus is termed negative and is situated at a point where the rays meet (see Fig. 194).

Actinic Focus.—Under the heading **Aberration** will be found some remarks concerning chromatic aberration, by which it will be seen that unless the lens be rendered achromatic the actinic or chemical focus does not coincide with the visual focus. To make this clearer we have in Fig. 195 the focus of a non-achromatic lens. Its visual focus is at V, while its chemical focus is at C. The ground glass of the camera would be placed at V. and the image focused to the eye, but the chemical focus being at C it would be necessary to push it to that point, in order to get a sharp negative. Most modern lenses are, however, achromatized. The method by which this is performed is explained in *Chromatic Aberration* under **Aberration.**

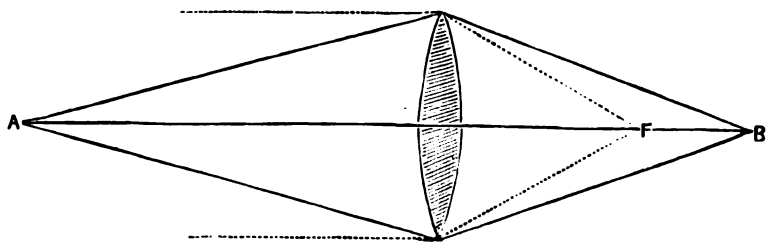


FIG. 193.

Depth of Focus of a lens is its power of rendering a sharp image upon the plane ground glass screen of objects situated at varying distances. A lens working at full aperture rarely renders near and remote objects perfectly clear at the same time. By using a diaphragm a portion of the rays is cut off, and a much greater depth of focus is obtained, but with the sacrifice of illumination, necessitating increased exposure. (See also **Diaphragm.**)

Equivalent Focus.—A term applied to a compound or doublet lens. It is the focus or parallel rays entering the lens, and is termed equivalent from being compared with a single lens producing the same size image when placed at the same distance from the object. To be perfectly correct, the point from which this focus should be measured is situated between the diaphragm slot and the back combination. It is, however, usually measured from the slot itself, and this measurement will usually be found sufficiently accurate if an object over 150 yards away be focused on the ground glass and the distance between the diaphragm slot and the screen be measured.

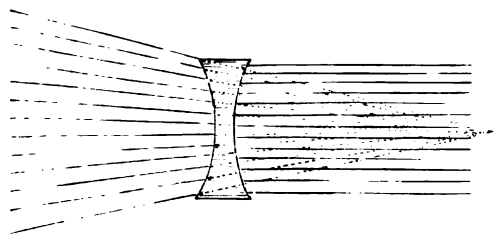


FIG. 194.

Grubb, the well-known optician, gives the following method for obtaining the true equivalent focus of a lens:—"Set the camera before a window upon a flat table, upon which is

spread a sheet of white paper. Focus upon some distant object about 150 or 200 feet away. Draw two upright lines on the focusing screen at one inch from the right and left sides respectively. Make the focused image fall on one of these lines, and with a pencil draw a line upon the paper along the side of the camera. Now move the camera so that the image appears on the other line, and draw another mark alongside the camera. Take away the camera, and continue these lines with a ruler until they meet to form an angle. Next draw a line across to form a triangle, the line being exactly the same length as the distance between the two lines on the screen. Find the centre of this line, and connect it with the junction of the two angular lines; this will represent the true equivalent focus of the lens. Example: Lines A A, B B (Fig. 196), are those made on the white paper by the sides of the camera. These lines are extended until they meet at C. E D is the distance of the two pencil lines drawn on the focusing screen. F is the centre of this line and F C the equivalent focus of the lens."

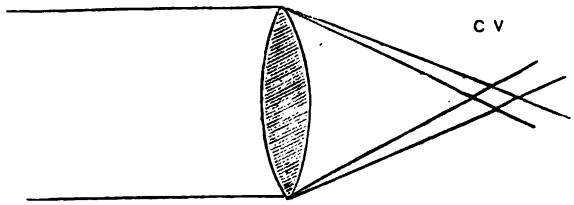


FIG. 195

Abney in his instruction book, gives the following method of discovering the true equivalent focus of the lens:

Measure a distance of, say, one hundred feet away from a fixed point, and place a rod at one extremity. From this point measure a line of some forty feet in length at exactly right angles to the first, and place another rod at the other end. Next place the front of the camera containing the lens to be tested exactly over the starting point of the first line, and level it, the lens being in the direction of the first line. Having marked a central vertical line on the ground glass with a pencil, focus the first rod accurately so as to fall on the pencil line on the ground glass. Take a picture of the two rods in the usual manner, and measure back as accurately as possible the distance of the centre of the ground glass from the starting point, and also the distance apart of the two images of the rods (at their base) upon the resulting negatives.

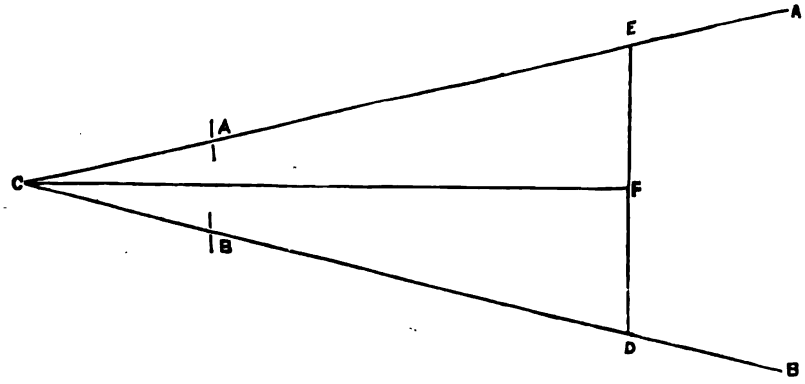


FIG. 196

Suppose the first measured line A B (Fig. 197) be 149 feet, B D the second line to be 35 feet, A C to be 1 foot, and E C the distance apart of the two images to be three inches, F being the point where D E cuts C B. Then B D + CE : CB : : CE : CF, which is the equivalent for focal distance. Here CB = 150 feet, BD + CE = 35.25 feet, CE = .25 feet.

$$\therefore CF = \frac{150 \times .25}{35.25} = 1.063\text{ft.}$$

This gives us the equivalent focal distance, which is the distance of the ground glass from the optical centre of the lens. The thickness of the ground glass having been previously taken, the distance should be set off from its smooth side on to the brass-work of the lens. This point, which is the optical centre, should be clearly marked on the lens, as from it all measurements can be calculated, and the knowledge of its position will be found very useful.

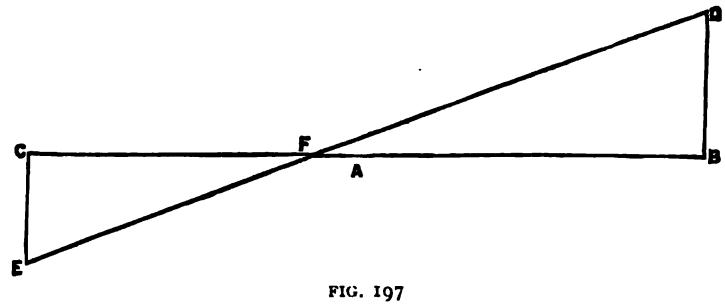


FIG. 197

A very simple method of ascertaining the equivalent focus of a doublet lens is to multiply the foci of the two combinations and divide by the sum obtained by adding them together, and subtract the distance of separation, the result being the equivalent focus of the two lenses combined. For example, we require to know the equivalent focus of a lens, the front combination of which has a focus of 10 inches and the back of 8 inches, while they are separated from each

other by a space of 2 inches, then $10 \times 8 \div [(10 + 8) - 2] = 80 \div 16 = 5$ inches, the true equivalent focus.

After a certain distance all objects will be in focus. The following table* will be found useful for many purposes. It shows at a glance the distance beyond which all objects will be sharply defined, and it is a good plan to mark the stops with this distance, so that if a subject be taken requiring a particular stop to obtain correct focus, and it is discovered that this stop requires too long an exposure, the subject should not be taken, and thus a plate will be saved For detective camera work this table is very useful.

TABLE OF DISTANCES AFTER WHICH ALL OBJECTS WILL BE IN FOCUS.

Focus of lens in inches.	Decimal Standard Stop Numbers.								Ratio Marked on Stops.													Focus of lens in inches.
	5	10	15	20	25	50	35	40	*f*-7	*f*-8	*f*-9	*f*-10	*f*-11	*f*-12	*f*-13	*f*-14	*f*-15	*f*-16	*f*-17	*f*-18	*f*-19	*f*-20	
	Number of feet and inches after which all in focus.								Number of feet and inches after which all in focus.														
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
4	19·4	13·8	11·5	9·10	8·9	8·0	7·5	7·0	19·4	17·0	15·1	13·8	12·5	11·5	10·7	9·10	9·2	8·8	8·2	7·8	7·4	7·0	4
4½	21·10	15·4	12·10	11·1	9·10	9·0	8·4	7·10	21·10	19·2	17·0	15·4	14·0	12·10	11·10	11·1	10·4	9·9	9·2	8·8	8·3	7·10	4½
4½	24·5	17·3	14·5	12·5	11·1	10·1	9·4	8·9	24·5	21·5	19·1	17·3	15·8	14·5	13·3	12·5	11·7	0·11	10·3	9·9	9·3	8·9	4½
4¾	27·3	19·2	16·0	13·9	12·4	11·3	10·5	9·9	27·3	23·10	21·3	19·2	17·5	15·0	14·10	13·9	12·11	12·1	11·5	10·10	10·3	9·9	4¾
5	30·2	21·3	17·9	15·3	13·7	12·5	11·6	10·10	30·2	26·5	23·6	21·3	19·4	17·9	16·5	15·3	14·3	13·5	12·8	11·11	11·4	10·10	5
5½	33·3	23·4	19·6	16·10	15·0	13·9	12·8	11·11	33·3	29·1	25·11	23·4	21·3	19·6	18.1.	16·10	15·9	14·9	13·11	13·2	12·6	11·11	5½
5½	36·5	25·8	21·5	18·5	16·5	15·0	13·10	13·0	36·5	31·11	28·5	25·8	23·4	21·5	19·10	18·5	17·3	16·2	15·3	14·5	13·8	13·0	5½
5¾	39·10	28·0	23·5	20·1	17·11	16·5	15·2	14·3	39·10	34·11	31·1	28·0	25·6	23·5	21·8	20·1	18·10	17·8	16·8	15·9	14·11	14·3	5¾
6	43·4	30·6	25·6	21·11	19·6	17·8	16·6	15·6	43·4	38·0	33·10	30·6	27·9	25·6	23·6	21·11	20·6	19·3	18·1	17·2	16·3	15·6	6
6½	47·0	33·0	27·7	23·9	21·2	19·4	17·10	16·9	47·0	41·2	36·8	33·5	30·1	27·7	25·6	23·9	22·2	20·10	19·8	18·7	17·7	16·9	6½
6½	50·10	35·9	29·10	25·8	22·10	20·11	19·3	18·1	50·10	44·6	39·7	35·9	32·6	29.10	27·7	25 8	24·0	22·6	21·3	20·1	19·0	18·1	6½
6¾	54·9	38·6	32·2	27·8	24·8	22·6	20·9	19·6	54·9	48·0	42·9	38·6	35·0	32·2	29·10	27·8	25·10	24·3	22·10	21·7	20 6	19·6	6¾
7	58·11	41·5	34·7	29·9	26·6	24·3	22·4	21·0	58·11	51·7	45·11	41·5	37·8	34·7	31·11	29·9	27·9	26·1	24·7	23·3	22·0	21·0	7

FOCUS ADJUSTER.—An arrangement fitted to a lens, and by means of which the focus can be adjusted to different lengths for various purposes. Traill Taylor in his work on photographic optics there describes a convenient form devised by himself. It consists in a sliding piece of brass made hollow in order to secure lightness. This contains four apertures, into each of which is fitted a thin achromatized lens of a negative power. This piece slides through the lens mount by means of an aperture. The combination to which this system is attached is a doublet composed of two slightly meniscus lenses, which, when used alone, do not give a flat field. By inserting the slide the influence of either of the four concave lenses contained in it is to flatten the field and lengthen the focus—the marginal pencils being well corrected with a moderately large aperture. With No. 1 lens the focus was 7 inches, with No. 2 it was lengthened to 9, with No. 3 to 12, and with No. 4 it was increased to 15 inches.

FOCUSING.—The act of bringing the image into focus. When the camera is set up it should be racked out to its equivalent focus, which, for convenience sake should be marked on the baseboard of the camera. The cloth is then covered over the head, and an object about midway in the middle distance of the view is sharply focused. The image of nearer objects will be indistinct, however. The stops are then inserted in order, commencing with the largest until the whole of the image becomes as clearly defined as desired. It is not always advisable, from an artistic point of view, to stop the lens down so completely that every object near and far is in focus. Many pictures require the principal object in the foreground to be sharp, the objects in the background being thrown out somewhat. For obtaining very sharp images the ground glass screen system is often very imperfect. The telescopic method devised by Taylor will be found far more perfect, and, further, permits of a moving object being focused while the plate is in the camera ready for exposure. A small telescope is obtained of exactly the same focus as the lens. The front part is attached to a pin fitted to the front part of the camera, and the eyepiece end is attached to the frame of the camera which contains the plate-holder. Care must be taken in fitting this part that the telescope and the camera are exactly in focus together. The image on the screen must be carefully examined with a magnifier. The quality of the ground glass will be found very important in focusing. See **Focusing Screen.**

FOCUSING CLOTH.—A black cloth used for covering over the head and back portion of the camera to exclude all extraneous light, and to allow of the examination of the image thrown by the lens upon the focusing screen. The cloth used is either black velvet, twill, or waterproof cloth. This latter material is the most serviceable, as it serves as a convenient waterproof covering for the camera in case of sudden showers. The cloth should always be of sufficiently large dimensions, about 36 to 40 inches square is about right, although for a large camera it would have to be bigger. It should be fitted with buttons and loops, so that it can be secured to the camera

* Compiled by Sir D. Salomons.

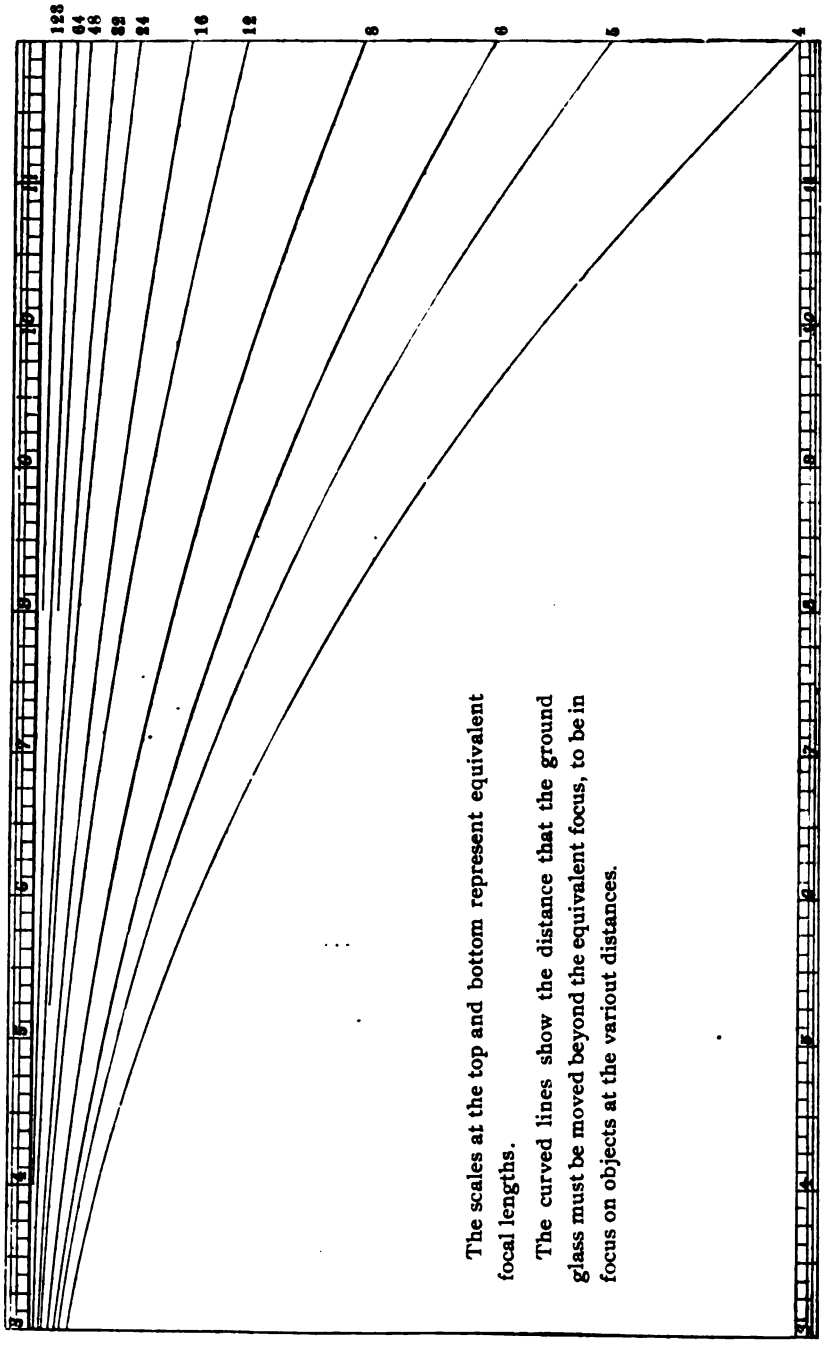
if the weather be windy. Other methods for shutting out the light have been devised, but it will be long ere the black cloth is superseded.

FOCUSING GLASS. — Also called the focuser, focusing magnifier, compound focuser, etc. A magnifying glass fitted in a tube, and so arranged that the image upon the focusing glass is exactly in focus with the lens of the magnifier. By its means microscopic sharpness of focus can be obtained, which is almost a necessity if the negatives are intended to be enlarged. The magnifying glass is usually composed of two plano-convex lenses, equal in all respects, and mounted with their plane sides outwards at a distance equaling two-thirds of the focal length of the lenses. It is preferable that the lenses should be achromatic, although this is not absolutely necessary. A convenient form of focusing glass is seen in Fig. 198.

FOCUSING SCREEN.— The material upon which the image formed by the lens is seen. This is usually a piece of ground glass of the best quality. It can be made by grinding a piece of patent plate glass with very fine emery powder. The most convenient plan is to grind two pieces together by firmly securing one piece to a table and rubbing over it a paste of fine emery powder and water. The second piece of glass is then laid on and rubbed over the other in all directions. The upper piece of glass can be best manipulated by employing a pneumatic holder to lay hold of it. Another method of preparing glass is by treating it with hydrofluoric acid, which gives it a dull matt surface superior to ground glass. See **Hydrofluoric Acid.**

FOCUSING SCALES FOR ANY LENS OF FROM 3 TO 12 INCHES EQUIVALENT FOCUS.

Drawn by W. T. WINTRINGHAM.



By oiling the ground glass the detail of the image is seen better. If the ground glass should happen to get broken, and another not easily obtainable, a rough temporary substitute can be made by coating a piece of glass with a paste of flour and water, or even a piece of tissue paper or fine cambric handkerchief can be used.

There have been many substitutes for ground glass recommended. A glass plate coated over with a matt varnish of—

Sandarac	18 grains.
Mastic	4 "
Ether	200 mins.
Benzole	100 "

will make an excellent focusing screen, or even an ordinary varnish can be used if a little tartaric acid be added, and the varnish applied cold.

A paper focusing screen can easily be made with a piece of strong, but thin,paper, rendered translucent. (See **Translucence.**)

Carey Lea coated glass with an emulsion of barium sulphate, made by dissolving thirty grains of gelatine in an ounce of water, and adding a small quantity of ammonium sulphate and a solution of barium chloride, stirring the while.

The side of the focusing screen next to the lens should be in exactly the same position that the film of the dry plate or other sensitive medium will occupy, otherwise unsharp images will be the result.

FIG. 198.—FOCUSING GLASS.

It is a good plan to mark the focusing screen, as shown in Fig. 199, with the different sizes smaller than the camera is intended for, so that working with smaller plates the position of the view is plainly seen. The upright lines are also useful in detecting the verticality of architectural subjects, etc.

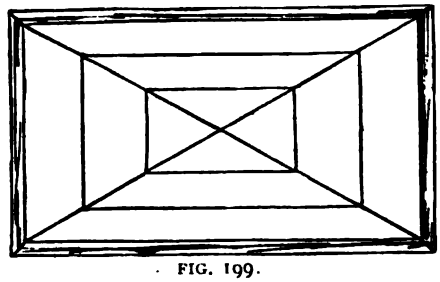


FIG. 199.
FOCUSING SCREEN WITH LINES DRAWN.

FOG.—A very common defect in gelatine negatives. It appears as a veil covering the whole or part of the negative, and may be due to faulty emulsion, to the admission of stray light in the camera or elsewhere, or it may be due to over-exposure or to faulty development.

Chemical Fog.—When the error can be traced to the emulsion itself, it is thus termed. It usually makes its appearance as—

Green Fog.—It appears green by reflected, and pink by transmitted light, being dichroic. It is produced by reduced metallic silver in a fine state of division, and also by the gelatine becoming decomposed by prolonged heating in the cooking process. The plates should be immersed in a strong solution of potassium dichromate, and then well washed. If any of the emulsion itself be left it should also be treated to the dichromate solution by squeezing it into the latter through coarse canvas, and afterwards well washing in water. It is as well to mention that this treatment will not always affect a cure, but it has been known to do so on many occasions, and is therefore well worth trying.

Plates liable to green fog should be developed with ferrous oxalate or a potash and soda developer, as there is less likelihood of it appearing with these developers than with ammonia.

Green fog may be eliminated from a plate by treating it after fixing and washing to a bath composed of—

Ferric chloride	50 grains.
Potassium bromide	30 "
Distilled water	4 ounces.

for about two or three minutes. This serves to convert the image into silver bromide, and at the same time to bleach the green fog, and reduce the density of the negative. A ferrous oxalate developer is then applied, and the negative brought up to its required density, when it is refixed and washed.

Dr. Meniéré advises the following treatment for removal of green, red, yellow, or dichroic fog. Soak the negative in plain water for five minutes and then remove it.

Water	100 c. c.
Bromide of sodium	3 grains.
Bromine water	3 c. c.

Let it rest in this for ten or fifteen minutes. The bleached image is then well washed and the image redeveloped with an amidol sulphite developer.

Red Fog occurs when the silver nitrate is in excess of the salts with which it should combine in the emulsion. A careful study of the tables given on pages 181 and 182 will prevent this. The only remedy for this kind of fog is potassium cyanide, but its action is uncertain, and it is highly dangerous to use.

General Fog is produced in development, and is caused by the partial reduction of the silver salt all over the film. This may also be due to the decomposition of the gelatine by prolonged heating. The products of the decomposed gelatine in the presence of the developer have a ten-

dency to react on the silver salt, producing partial reduction and general fog. It has been noted that in stormy weather, when the air is charged with electricity, that this defect is more easily produced. The remedy is to add a few drops of a carbolic acid solution to the gelatine solution during the cooking process. This will usually prevent decomposition.

Light Fog is caused by the action of light upon the whole or a portion of the film. The only actinic light that should reach the plate before fixing should be that light which enters through the lens and forms the image. Light fog may be caused by the light of the room in which the plates are made (or placed in the plate-holders) being too actinic. It very often happens, however, that the camera or plate-holder is at fault. If there is any defect in the camera producing fog the edges of the plate which are covered by the rabbet of the slide will remain clear.

To examine the camera take it out into strong sunlight, place the cap on the lens, remove the focusing screen, and, with the black cloth covered over the head, make a thorough examination of the inside of the camera (racked out to its full extent), and see if there are any holes or other places where light is admitted. If the dark side be at fault the fogging will usually be in streaks. The inside of the camera and slides should be painted a dull black, as fog is easily produced by reflecting surfaces.

Fogged plates will be produced if white light be not excluded from the dark room, or if the light employed be too actinic.

A peculiar kind of fogging sometimes makes its appearance round the edges of plates, and is due to some impurities in the strips of paper placed at the edge of the plates to separate them.

In the collodion process the principal causes of fog are—the alkalinity of the silver sensitizing bath, or the neutrality of the same if a bromo-iodized collodion be employed. Other causes may be in over-acidity of the bath, diffused light in the camera, dark-room, etc.

FOLDING RACKS.—See **Racks.**

FORMALIN.—Formalin is the trade name given by the manufacturers to a saturated aqueous solution of formic aldehyd (CH_2O), the latter being a gaseous body prepared by subjecting methyl-alcohol to oxidization. The saturated solution contains about 40 per cent. of the aldehyd. It mixes with water in all proportions. If it be not kept properly corked, formalin gas evaporates. The evaporation is accelerated by heat, and the formalin in the form of a vapor can thus be utilized.

It appears that formalin is largely used as a disinfectant and as a deodorizing agent, it possessing an extraordinary active microbicide power similar to that of corrosive sublimate, but is comparatively non-poisonous.

The chief use that it is apparently destined to be put to by photographers is, however, due to its hardening effect upon gelatine. This, according to our experiments, appears to be far greater than and superior to alum or sulphite. We treated some plates to a one per cent. solution of formalin for about five minutes and under this treatment they become so hard that they were uninfluenced by boiling water. Some gelatine prints were also subjected to its influence. A very strong solution slightly changed their color, but apparently no advantageous effect is produced by using a concentrated solution. In a mixture of one per cent. of formalin in water no change in color was produced, and the prints became so hard that they would stand almost any amount of handling and the film could not be dissolved.

Taking a small test tube we half filled it with a ten per cent. solution of gelatine. When this had solidified we poured into the top a small quantity of formalin solution. In a few hours this had penetrated to the depth of nearly half an inch, its action being apparent by its clarifying effect which is peculiarly remarkable and worthy of more attention.

This penetrating power gives us the reason why its action upon the film is so rapid, and why a very dilute solution can be employed.

Gelatine acted upon by formalin and rendered insoluble is termed "formalin gelatine." In a recent number of the *Therapist* is an article in which the substance is recommended for microscopic preparations of bacteria. The bacteria colonies are developed in the gelatine and fixed by the application of formalin in solution or by the vapor. By this method the cultures maintain their natural appearance, and staining can be carried out as usual, as the formalin does not attack the coloring solution. The gelatine plate—laid in a dilute, aqueous fuschin solution for twenty-four hours, acquires a delicate rose tint, while the bacteria are stained a deep red.

As a substance of service to the photographer, formic aldehyd, says the *British Journal of Photography*, is likely to attract further notice. It has already been shown what a powerful tanning it exerts upon gelatine, and a printing process has now been devised and patented by the *Chemische Fabrik auf Actien*, of Berlin, in which this property of formic aldehyd is utilized, in conjunction with another well-known property, and one common to all the aldehyds, viz., that of readily taking up oxygen from any substance capable of employing it, such substances, for instance, as ferric salts. The process consists in treating gelatine films, which have been rendered insoluble by means of formic aldehyd, with a solution of a ferric salt. On exposure to light under a negative, the ferric salt is reduced to the ferrous state, and the oxygen

disengaged in the process is transferred to the formic aldehyd, converting it into formic acid, with the result that, where this oxidization of the aldehyd has taken place, the gelatine film is rendered soluble again. By this means, therefore, a positive image is obtained from a positive on development by washing.

A modification of the process is also patented, whereby a positive print may be obtained from a negative. To this end the formic aldehyd is first converted into its so-called "sulphite" a compound which does not render gelatine insoluble. A gelatine film previously treated with this sulphite, and impregnated also with a ferric salt, is exposed to light, the result being that, in the parts where light is transmitted, the sulphite is oxidized through the agency of the reduction of the ferric salt, and the formic aldehyd is thus liberated with the subsequent reduction of insoluble gelatine in these same portions.

According to Mr. Roy negative films, after being hardened with formalin, can be readily stripped from the glass without unequal contraction or enlargement. The plate is first treated with a rather strong formalin bath, and the film is cut through at the edges, when the plate is immersed in a 20 per cent. solution of sodium carbonate, and then, without rinsing, in 5 to 10 per cent. hydrochloric acid. Carbonic acid is now disengaged under the film and it floats off. It is convenient to receive it on collodionized glass and then to collodionize the other side, and when removed from this glass the pellicular negative is quite flat and convenient for handling.*

FORMIC ACID (H. COOH, hydrogen, carboxylic acid; molecular weight, 46).—It was first found in the red ant (*Formica rufa*), hence its name. The original method of preparing it was by distilling these ants with water. It occurs, however, in many plants and fruits, in the products of oxidation of crude turpentine, oil, etc. It is usually prepared by the oxidation of wood spirit.

Formic acid is a colorless liquid of a pungent odor. It freezes at 30 degs. and boils at 210 degs., giving an inflammable vapor, which burns with a blue flame. It is a powerful reducer of the salts of silver and mercury, and has been recommended as a retainer in the developer.

Mixable with water and alcohol in all proportions.

FORMIL CHLORIDE. See **Chloroform.**

FORMULA. — The term is used in chemistry to denote a collection of symbols representing a compound. The formula of a compound is written by placing side by side the symbols of the elements which it contains, and also the small figures indicating the number of combining proportions of each element which are present in the compound represented, or, in other words, the chemical formula of a compound is intended to represent the quantitative composition of the compound, and to tell what atoms and how many are combined to make the smallest particles of the compound itself. The method by which formulæ are determined is this:—First the substance must be analyzed, and secondly the molecular weight must be determined. We will take, for example, water. By analyzing this compound called water we find it consists of hydrogen and oxygen, 1 part of the former and 8 parts of the latter, both by weight. We have next to determine the specific gravity of water vapor, and find that, as compared with air, its specific gravity is 0.623. We have now the relative weight of the molecule of water, and by adopting the usual standard it shows the molecular weight to be 18. The atomic weight of oxygen is 16, and that of hydrogen 1. So we now have all we require for writing the formula. A molecule, consisting of hydrogen and oxygen in the proportions given, and the weight of which is 18 in terms of accepted unit weight, must contain two atoms of hydrogen and one atom of oxygen. The formula is therefore written H_2O or OH_2.

Mercurous chloride contains one combining portion of mercury and one of chlorine; its formula is therefore written HgCl. Mercuric chloride, however, contains one combining proportion of mercury and two of chlorine; its formula is $HgCl_2$. In the table of elements is given their respective symbols, by which it will be found easier to understand the formulæ given.

Chemical formulæ have a quantitative besides a qualitative meaning; for instance, HgCl, not only signifies that mercurous chloride is composed of mercury and chlorine, but it also means 235.4 of mercurous chloride composed of 200 parts of mercury and 35.4 of chlorine. These numbers will be found opposite to the elements. Formulæ of compounds have still another meaning, which it is neccssary to understand. They always represent one molecule, and the numbers indicate the number of atoms of the different elements in that molecule. For instance, $K_2Cr_2O_7$ serves to represent one molecule of potassium dichromate, consisting of two atoms of potassium weighing 39.1 each, two atoms of chromium each weighing 52.3, and seven atoms of oxygen weighing 16 each. By adding the weights of all the atoms we get the molecular weight. (See also **Chemistry.**) The chemical formulæ of each substance is given under the respective headings.

The word formula is also applied to recipes for making compounds expressed in ordinary words and figures.

FOTHERGILL PROCESS.—A dry process introduced by Fothergill in 1858. In this

* *The British Journal of Photography.*

sensitive collodion plates were washed, first in distilled water, and then in the usual developing solution of pyrogallic acid, after which they were dried and kept till required.

FRACTIONAL DISTILLATION. See **Distillation.**

FRAUNHOFER LINES.—Certain dark lines in the solar spectrum discovered by Fraunhofer. If a ray of light be admitted through a narrow slit in a dark room, and this slit examined through a prism of flint glass, besides the spectrum band of colors, a number of lines will be observed delicately traced parallel to the edge of the prism, and at unequal distances from each other. Fraunhofer distinguishes the most remarkable of these lines by the letters A, a, B, C, D, E, b, F, G and H. A is at the beginning of the red ray, B in the middle, and C at the boundary between it and the orange, E in the green, F in the blue, G in the indigo, and H in the violet; *a* is in the red and *b* in the green. Since Fraunhofer's time, however, some three thousand or more of these lines have been discriminated, some being fixed in position, and others are variable. The latter are often termed telluric or atmospheric lines, as it is probable that they are due to the absorption of the air. The study of these lines has led to a method of analysis termed spectrum analysis, to which photography has been essentially useful. (See also **Spectrum.**)

FREEZING.—The transformation of a liquid into a solid by the influence of cold. A liquid always solidifies at the same temperature, which is termed its freezing point, and the solid returns to its liquid state at the same temperature, the freezing point and the melting point being always the same for each substance.

The freezing point of water or the melting point of ice is 32 degs. Fahr., and is taken for one of the fixed points in thermometrical calculations. The freezing point of mercury is 39 degs. below zero, of sulphuric ether 46 degs. below zero, and of alcohol 203 degs. below zero Fahrenheit. By increasing the pressure upon water or upon any substance which expands when freezing, its freezing point will be lowered, but with such substances as wax, sulphur, paraffin, etc., which contract in freezing, the freezing point is raised by increasing the pressure.

FREEZING MIXTURES.—In warm weather it is often useful to have some means of lowering the temperature of a liquid. Artificial freezing is obtained by the liquefaction of solids or the evaporation of liquids. The following table gives the most important freezing mixtures, and shows the number of degees the thermometer falls :—

FREEZING MIXTURES WITHOUT ICE.

	MIXTURES.	PARTS BY WEIGHT	THERMOMETER SINKS.	DEGREES OF COLD PRODUCED.
1	Ammonium nitrate	1	From + 50° to + 4°	46°
	Water	1		
2	Sodium Sulphate	8	From + 50° to − 0°	50°
	Hydrochloric acid	5		
3	Sodium Sulphate	3	From + 50° to — 3°	53°
	Dilute nitric acid	2		
4	Ammonium nitrate	1	From + 50° to — 7°	57°
	Sodium carbonate	1		
	Water	1		
5	Sodium sulphate	6	From + 50° to — 10°	60°
	Ammonium chloride	4		
	Potassium nitrate	2		
	Dilute nitrate acid	4		

FREEZING MIXTURES WITH ICE.

	MIXTURE.	PARTS.	THERMOMETER SINKS FROM ANY TEMPERATURE.
1	Snow or powdered ice	2	to — 5°
	Sodium chloride	1	
2	Snow or powdered ice	5	to — 12°
	Sodium chloride	2	
	Ammonium chloride	1	
3	Snow or powdered ice	12	to — 25°
	Sodium chloride	5	
	Ammonium nitrate	5	

A mixture of snow and potash will reduce the temperature from + 30 degs. to — 51 degs., producing 83 degs. of cold.

A very intense cold can be produced by the evaporation of a mixture of solid carbonic acid and sulphuric ether, a temperature of 166 degs. Fahrenheit below the freezing point of water being obtained. Natterer obtained a temperature as low as—220 degs. Fahr. by evaporation *in vacuo* of a mixture of liquid nitrous oxide and carbon bi-sulphide.

FRENCH CHALK.—A variety of talc usually sold in a finely powdered state. It is used for cleaning glass. If a glass be rubbed over with French chalk, and then be coated with a film of gelatine or collodion, the same will not thoroughly adhere to the glass, but can be removed when dry. Gelatino-chloride prints are squeegeed on to glass rubbed with French chalk, and when dry they can be peeled away, leaving a beautiful polished surface. French chalk also acts as a lubricant for woodwork, but is not superior to finely powdered blacklead.

FRILLING.—A defect common to the dry plate process. The gelatine leaves the glass in frills or wrinkles. It generally commences at the edge of the plate, and is extremely annoying. It usually occurs when the plate is being fixed, but is sometimes met with in developing, more especially in warm weather.

The causes of frilling are numerous. It may be that the gelatine used in the emulsion possesses too little tenacity. Emulsions that have been boiled for a long time to obtain great sensitiveness are peculiarly liable to frilling. The addition of a small quantity of chrome alum will often prevent it; in adding it, however, it should be done sparingly, as it increases the tenacity of the gelatine and makes development more difficult. If the glass plate upon which the emulsion is spread has not been properly cleaned, the emulsion will leave the glass in frills, or it may also be caused by unequal drying. In the latter case the plates must be dried by means of alcohol, or in a suitably constructed drying cupboard. The best and most effectual remedy to prevent frilling is to coat the plate with a collodion formed of tough pyroxyline 6 grains, alcohol (·820) half-ounce, ether (·725) half-ounce, applied before developing the plate. The solvents are removed by washing in clean water previous to development.

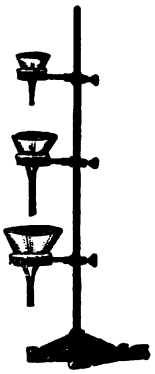


FIG. 200.
FUNNEL STAND.

If the plates have been properly made, however, frilling is more often caused by the operator himself by allowing too strong a force of water to strike the edge of the plate, or by using too strong a developer. The following remarks will be found useful in warm weather when plates are particularly liable to frill:—First, the water and solutions used in developing, fixing, and washing the plate should all be of equal temperature. Secondly, a small drop of methylated spirit should be added to the developer. Thirdly, after developing, the plate should be rinsed under the tap and laid for a few minutes in pure methylated spirit. Fourthly, the fixing bath should not be too strong. Fifthly, after fixing rinse the plate well under the tap, and then place for five minutes in a saturated solution of alum. Sixthly, well wash in a dozen or more changes of water, and soak the plate for ten minutes in methylated spirit. Remove it, and it will dry in about ten minutes.

If these instructions be carried out no frilling will result even in hot climates.

It is a good plan in developing to have in readiness a dish containing methylated spirit or chrome alum solution. Immediately any signs of frilling make their appearance, the plate is rinsed under the tap and placed in this bath for a few minutes, after which development is proceeded with.

FRONT FOCUS.—See **Focus**.

FULLER'S EARTH.—A variety of clay or marl of various colors, usually of greenish tint. It is very useful for cleansing purposes, as it absorbs grease. It is composed of silica 50, alumina 20, water 24, and small quantities of magnesia lime and peroxide of iron. It is found in large quantities in several parts of England.

FULMINATING POWDER.—The substance generally known as fulminating powder is composed of three parts of nitre, two parts of dry carbonate of potash, and one part of flower of sulphur, reduced to a fine powder before mixing.

FUMING.—A process of subjecting albumenized paper to the fumes of ammonia, by which means the paper prints a trifle quicker, the prints are more brilliant, and the purple tone, so much admired, is more easily obtainable. In America the fuming of paper is considered a great point, but it is hardly ever practiced in England.

Fuming is accomplished by placing a little strong ammonia at the bottom of an air-tight box, and pinning the sensitized albumen paper to the lid, film side downwards. The lid is then closed tightly, and the fumes of the ammonia act upon the surface of the paper. About ten minutes in warm and 15 in cold weather will suffice to complete the process. Fumed paper should

be used within a day or two after fuming, as the effect is not permanent. Fumed paper also discolors more rapidly than unfumed.

FUNNEL.—A conical vessel which terminates below in a spout, and is used for conducting a liquid into a vessel having a small opening. For photographic purposes fnnnels are usually made of glass or ebonite. They are also very useful for filtering liquids through filtering paper, and for this purpose ribbed funnels are to be preferred. If made of glass it is much more easy to see if quite clean than with ebonite or gutta-percha funnels.

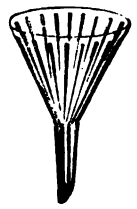


FIG. 201.
GLASS FUNNEL

FUSED NITRATE OF SILVER.—See **Silver Nitrate.**

FUSEL OIL.—A heavy oily inflammable fluid with a high boiling point, a disagreeable cutting odor, and a pungent taste. It is the oily product formed during the fermentation of potatoes, corn, and the juice of grapes.

FUSIBLE METAL.—An alloy usually of lead, tin, and bismuth compounded in such proportions as to melt at given temperatures—

8 parts of bismuth, 5 of lead, 3 of tin ; melt at 212 degs. Fahrenheit.
2 parts of bismuth, 1 of lead, 1 of tin ; melt at 201 degs. Fahrenheit.
5 parts of bismuth, 5 of lead, 4 of tin ; melt at 199 degs. Fahrenheit.

Another good fusible alloy is made with cadmium 2 parts, bismuth 8 parts, tin 2 parts, lead 4 parts. This composition melts at 160 degs. Fahrenheit.

An alloy of this kind is often useful for producing metal casts. If a metal cast be made of a gelatine relief, the same can be printed from in the same manner as the Woodbury or Stannotype process.

FUSION.—The act of fusing, melting, or becoming a liquid by heat. In chemistry. every substance begins to fuse at a certain temperature, provided the pressure be constant, The term is specially applied to the action of heat upon metals, but is extended to any solid matter. Platinum fuses at 3,082 degs. Fahrenheit, iron at 2,912 degs., steel at 2,552 degs., manganese and gold at 2,282 degs., copper at 1,922 degs., silver at 1,832 degs., bismuth at 512 degs., sulphur at 239 degs., iodine at 225 degs., potassium at 136·4 degs., acetic acid at 113 degs., ice at 32 degs., bromine at + 9·5 degs., sulphuric acid at — 30.00 degs., and mercury at — 37·9 degs.

GALLIC ACID (Formula, $C_7H_6O_5$; molecular weight, 170).—Exists in small quantities in gall nuts and in other vegetables. It is generally obtained from gall nuts, which in addition to gallic acid, usually contain a large quantity of tannin (tannic acid, or gallo-tannic acid). The gall nuts are boiled with water, and the solution filtered while hot. On cooling, gallic acid crystallizes out, and it may be purified by re-dissolving and boiling with a little animal charcoal.

It forms white silky crystals, having a sour taste. It is soluble in 3 parts of boiling water but in only 20 of cold. If the crystals are strongly heated, pyrogallic acid is produced, and sublimes over. Gallic acid was used in development in the wet-plate process, but was superseded by other reducing agents possessing more energy. In order to obtain excessive density with gelatine dry plates, they should be soaked in an aqueous solution previous to alkaline development. It is also used in the development of slightly printed paper containing free silver and intended for printing-out.

GALLON.—See **Weights and Measures.**

GALLO-NITRATE OF SILVER PROCESS.—An early process employed by Talbot in 1840. He discovered that if the sensitive paper used in the Talbotype process be brushed over with a mixture of gallic acid and silver nitrate, and be then exposed while in a wet state in the camera, the exposure time was considerably reduced. Another discovery was that the paper might be dried and exposed in that state, the image being afterward developed with gallo-nitrate of silver solution.

GALLS (synonyms, *nut galls*, *gall nuts*).—An excresence formed upon the branches and shoots of the *Quercus Infectoria*, or gall oak, produced by the puncture and deposited ova of the *Diplolepsis Gallæ Tinctoriæ*.

The best galls are imported from Aleppo, and sometimes called Aleppo balls. These balls are hard and very heavy—about half an inch or so in diameter. Their color varies from bluish green to light brown. They are largely used in the manufacture of gallic acids, tannin and pyrogallol.

GAMBOGE OR CAMBOGE.—An orange colored gum resin, chiefly produced from the *Garcinia Morella*, a native of Cambodia (hence the name), Siam, and Cochin China. When the bark of the gamboge tree is cut, the gamboge exudes as a thick, viscid yellow juice hardening on exposure to the air. It is generally collected in bamboo canes. The best quality should be of a

rich orange brown tint, and when broken should not show a rough, granular surface. Gamboge is sold in commerce in three forms, *i.e.*, in rolls of solid cylinders, in pipes or hollow cylinders, and in cakes. The latter is of inferior quality.

It is almost entirely soluble in alcohol, and forms with water a thick yellow emulsion, possessing but little smell or taste. It is employed in coloring, wood staining, and in coloring lacquers and varnishes. It is useful for painting out the skies or otherwise "dodging" negatives.

GAS AND GASES.—Gas is a term formerly applied to vapor that had not been condensed. It is now applied to vaporous substances not condensed into liquid form, at ordinary terrestrial temperatures and pressures, and also to those, which, at ordinary temperatures, are not condensable into a liquid by pressure only. In both these senses, therefore, air, under ordinary atmospheric conditions, is a gas, when cold enough it is not a gas but a vapor, and pressure alone will condense it.

The most dangerous gas that photographers deal with is hydrogen, used in the oxyhydrogen lime-light. (See **Hydrogen**, also other gases under their respective headings.)

GAS LIGHT is used in photography, chiefly for exposing bromide prints in contact printing. Its steadiness makes it preferable to ever-changing daylight. Gas light may also be used in the isochromatic process, especially for copying oil paintings, etc. It is but little used for portraiture, as the light obtained from a few burners is very non-actinic, and consequently the exposure would be very great. With a large number of burners, however, very good interiors may sometimes be made at night time.

GELATINE.—The word gelatine is derived from the Latin word *gelatus*, meaning frozen. It is so called because of the tendency the substance has of becoming solid. It is an animal gluten, obtained by boiling bones, hoofs, horns, and many other animal substances. Little is known of the chemical nature of gelatine, because it cannot be converted into vapor, and does not form well-defined compounds with other bodies. Its composition varies with the source from which it is obtained, but the following is about the average :

Carbon	50·1
Hydrogen	6·6
Nitrogen	18·4
Oxygen	24·8
Sulphur	0·1

The term gelatine, however, although usually applied to one variety of the substance, properly belongs to isinglass, glue, and other modifications of the same material. Vegetable jelly is also an analogous substance.

Gelatine is prepared for commercial purposes from a large variety of animal substances ; chiefly, however, from the softer parts of the hides of oxen and calves, and the skins of sheep and other animals. The parts used are usually the thin portions covering the belly, the ears, etc. The bones and other parts of animals are also used. The method usually adopted in making gelatine from skin parings or hide clippings is first to wash the pieces very carefully, after which they are cut into small strips and immersed in a weak solution of caustic soda for about seven or eight days. After this process of digestion is completed, the pieces of skin are transferred to revolving cylinders which are abundantly supplied with clean cold water. Here they are well washed and are then transferred, while still wet, to another chamber lined with wood. In this they are bleached and purified by exposure to the fumes of burning sulphur. The next process is to give a final washing in cold water to remove the sulphurous acid. After this they are squeezed as dry as possible and removed to the gelatinizing vessels, which are large earthenware pots, enclosed in wooden cases, made perfectly steamtight. Water is also poured in with the pieces, and the temperature is kept very high by means of the steam passing through the cases surrounding the pots. After a time the gelatine becomes completely dissolved out of the skin. It is then strained off, while hot and poured ont in thin layers. When set it is cut up into small oblong plates and laid on to netting, stretched horizontally, to dry. The cross markings observable on these plates of gelatine are caused by the meshes of the nets. When string nets are employed, small pieces of the hempen fibre will often be found adhering to the gelatine. When dissolved it should be carefully filtered.

The process of obtaining gelatine from bones is carried out in this manner. Bones are first digested in cold dilute hydrochloric acid till the calcium phosphate and other salts are dissolved, leaving a residue of the same form, but of a soft, flexible character. This is termed ossein, and has the same composition as gelatine, into which it can be converted by prolonged boiling with water.

Another process consists in treating pieces of calf-skin by water alone, without the soda and sulphur processes. The pieces, after washing, are transferred at once to the steam-heated pots.

Gelatine contains about 15 to 20 per cent. of water. It softens and swells in cold water, absorbing from five to ten times its own weight, but does not dissolve. Hot water dissolves it,

and the solution gelatinizes on cooling, even if it contains but one per cent. It is also soluble in acetic, oxalic, hydrochloric, and sulphuric acids; but is insoluble in alcohol, ether, and other organic liquids.

A good sample of gelatine will absorb a sufficient quantity of water to dissolve it when heated to 90 degs, Fahr., the solution setting to a jelly when cold. By the continued application of heat, gelatine loses its setting properties, a new compound, termed meta-gelatine, being said to be formed. It keeps indefinitely in a dry state, but when water is present it putrifies rapidly, the liquid becoming first acid and then alkaline, giving off ammoniacal vapors. To prevent speedy decomposition many antiseptics may be used. The principal are alum, alcohol, carbolic, salicylic, and boracic acid, thymol, hydrate of chloral, fuchsine, and zinc salts. Glycerine (in large quantities) will also act as an antiseptic. Alcohol will precipitate gelatine from its aqueous solution in white flakes. It is also precipitated by tannin, forming an insoluble, non-putrescible compound. By dry distillation gelatine yields a quantity of ammonium carbonate, and a vile-smelling brown, oily substance, containing carbonate, sulphide, and cyanide of ammonium, aniline, methylamine, picaline, and a number of pyridine bases. When boiled with strong alkalies, or with diluted sulphuric acid, it yields succine and glycocine (sugar of gelatine).

The uses of gelatine in photography are innumerable. It is used in the manufacture of emulsions, its duty being to hold the silver salts in suspension, and enable them to be spread over plates, paper, etc. For emulsion work a good quality of gelatine is essential. There are many ways of testing it. Dr. Eder recommends that the gelatine be incinerated, and the ash weighed. This should vary from ½ per cent. in good qualities, to 5 per cent. in inferior gelatine. When adulterated with alum the ash will sometimes reach 10 per cent. One of the best tests for gelatine is the amount of water it will absorb. This varies with good gelatine between 5 and 10 ten times its own weight. In the following table will be seen the percentage of ash obtained, and the absorbing powers of several of the best known gelatines:

	Gelatine.	Character.	Ash Per Cent.	Water Absorbed by 150 Gr.	Times Its Weight.
1	Coignet's gold label	hard	1	7 drachms	8½
2	" special	"	1	7 "	8½
3	Nelson's No. 1 Photographic	soft	2	5⅛ "	6¾
4	" opaque	hard	2	8 "	9¾
5	" amber	soft	1	4 "	5
6	French gelatine	medium	2	6 "	7¼
7	Swinborne's No. 2 pat. Isinglass	soft	1	5¾ "	
8	Cox's gelatine	"	1	4¾ "	5¾
9	Simeon's " Winterthur "	hard	1	7¼ "	8¾
10	Heinrichs	"	1	8 "	9¾
11	Batty's gelatine	soft	2	5 "	

It will be seen by this that the amount of ash left after incineration does not exceed 2 per cent.; also that the amount of water absorbed is in every case less than ten times its own weight. Another test is its solubility, as a gelatine which becomes soluble at too low a temperature would be quite unsuitable for emulsion making. When thoroughly soaked in cold water the temperature of the latter is gradually raised, and the degree of the thermometer noted when solution takes place. A further test must be made by noting the expansive power. This is important when plates or other substances are to be coated with it, as upon the expansive properties of the gelatine depends to a very considerable extent the frilling or non-frilling of the film. The greater the expansion, the greater the possibility of frilling or the film leaving the glass.

Abney, in his work on emulsion processes, gives the result of his experiments in this direction. He coated plates with the different gelatines, and dried them under the same conditions under which plates are dried in the drying box. The films were then stripped from off the plates, and different portions cut away, and accurately measured while dry. The films were then allowed to swell in water, ammoniacal water, or a solution of mono-carbonates of soda and potash, and again measured. Results:

Gelatine.	Dry.	Water.	Water and Ammonia.	Carb. Soda and Water.
Nelson's No. 1.	1	1.2	1.29	1.39
Autotype	1	1.09	1.28	1.21
Heinrich's	1	1.08	1.22	1.15
Simeon's	1	1.05	1.14	1.09
Batty's	1	1.32		
Nelson's X Opaque	1	1.19		
Crosse and Blackwell's	1	1.09		
Nelson's Amber	1	1.43		

The next important test is for acidity or alkalinity. This is easily done by test papers. For emulsion work a gelatine which is slightly acid is to be preferred.

Gelatine for photographic purposes is usually classed under three headings, *i. e.*, soft, medium, and hard. This term refers to the strength of a solution of given quantities, as tested by the power required to crush the jelly formed when cold. This hardness generally varies inversely as the weight of water which the sample will afford. Soft gelatine usually absorbs water

easily and quickly, requiring a low temperature to dissolve it, while a hard gelatine absorbs water but slowly and requires a greater temperature to cause its solution.

The quality of gelatine required for photographic purposes will depend considerably on the use to which it is to be put. For some purposes the commoner kinds can be used; while for others it will be necessary to employ only the fine sorts.

The property of alkaline dichromates to render gelatine insoluble and incapable of absorbing water when exposed to the light is the basis of the carbon process, and also of a large number of photo-mechanical printing processes. This peculiar property was first observed by Mungo Ponton about the year 1839, and was utilized by Poitevin in 1855.

Gelatine is also a sensitizer. Silver bromide mixed in collodion does not possess nearly so much sensitiveuess to light as if mixed in gelatine. Knopp, a German chemist, showed how gelatine is capable of combining with bromine, thus assisting the action of light in decomposing the silver bromide by attracting and uniting with the bromine given off from the silver salt under the action of light.

Other uses to which gelatine is put are based upon the fact that it is rendered insoluble by substances such as chrome alum without the action of light.

Gelatine dissolved in acetic acid forms a very useful substance, *i.e.*, liquid glue, retaining its adhesive properties, but losing its setting powers.

It also dissolves cold in a solution of barium chloride, and also, but to a lesser degree, in strontium chloride. This discovery was made in 1890 by MM. Lumière, who state* that with a solution of 15 per cent. of barium chloride the solubility is so great that sufficient gelatine may be dissolved to render the solution syrupy. The liquid keeps well and does not decompose. This property may be made useful in recovering residues from emulsion. The gelatine is dissolved in the chloride and diluted, when the haloid salts fall to the bottom of the vessel, and the liquid can be decanted. Bolton observed that 1 ounce of crystallized barium chloride dissolved in 6 ounces of water will readily dissolve 130 grains of Coignet's gelatine, the time occupied being about two hours, at a temperature of 65 degrees Fahr.

Corrosive sublimate, platinic chloride, cadmium bromide, chrome alum, formalin, and chlorine gas will cause gelatine to become insoluble.

GELATINE DRY PLATES.—Plates usually of glass coated with a film of gelatine containing sensitive silver bromide. (See **Dry Plates.**)

GELATINE EMULSION.—An emulsion of gelatine containing a sensitive silver compound. (See **Emulsion.**)

GELATINE MOUNTANT.—A mountant composed of gelatine. A good formula is—

Gelatine	1 ounce
Water	3 ounces
Alcohol	3 ounces
Glycerine	½ ounce
Carbolic acid solution	10 drops

This is especially suitable for mounting gelatine emulsion pictures to which a gloss has been given. (See **Mountant.**)

GELATINE NEGATIVE.—A negative produced on a gelatine dry plate. (See **Negative.**)

GELATINE RELIEF.—An image composed of gelatine in relief. It is prepared by means of a thick film of gelatine, containing a pigment, sensitized with potassium dichromate. This is exposed under the negative for somewhat longer than required in carbon printing. The action of the light is to render certain parts insoluble. The development is almost the same as with that process, though much more prolonged. The soluble parts are washed away in warm water, leaving those portions standing that receive the action of the light. The relief thus obtained is hardened with alum and dried. The basis of the Woodburytype process lies in the production of a suitable gelatine relief; under this heading (**Woodburytype**) will therefore be found a clearer and more detailed description of its manufacture.

GELATINO-BROMIDE EMULSION.—A gelatine emulsion containing silver bromide. (See **Emulsion.**)

GELATINO-CHLORIDE EMULSION.—An emulsion of gelatine containing silver chloride. There are two kinds; the one with which the image is made by the light is a latent one and rendered visible by development, and the other contains a certain percentage of free silver nitrate, and the image is printed out direct by the action of light. (See under **Emulsion.**)

GELATINO-CHLORIDE EMULSION PAPER.—A paper coated with a gelatino-chloride emulsion, containing a large quantity of citrate. It prints out in the same manner as with albumen paper, although much quicker. The image should be a little darker than required for the finished paper.

* Moniteur de la Photographie.

The prints are first washed in two or three changes of water, and are then ready for toning. Almost any toning bath can be used, the tones varying with the different formulæ used, so that the operator can select any bath. The following are recommended:

TUNGSTATE TONING BATH.

Sodium tungstate	¼ ounce
Gold chloride	4 grains
Water	20 ounces

ACETATE TONING BATH.

SOLUTION 1.

Sodium acetate (re-crystallized)	½ ounce
Gold chloride	4 grains
Water	20 ounces

SOLUTION 2.

Ammonium sulphocyanide	100 grains
Gold chloride	2 grains
Water	8 ounces

Keep. No 1 and 2 separate. For toning take in the proportion of twenty ounces of No. 1 to six ounces of No. 2.

After toning the prints are fixed in a solution of sodium hyposulphite, two ounces to twenty of water.

Or the following method of toning and fixing in one operation may be employed. The bath is made up of—

Water	24 ounces
Sodium hyposulphite	6 ounces
Ammonium sulphocyanide	1 ounce
Sodium acetate	1½ ounces
Alum (saturated solution)	10 ounces

Fill the bottle containing the solution with scraps of sensitized paper, spoilt prints, etc., which have not been fixed. Stand in the open air for a day, and filter. Then add—

Ammonium chloride	30 grains
Gold chloride	15 grains

With this bath the operations of washing, toning, and fixing are reduced to one. The prints are plunged into the solution without any previous washing, and are there allowed to remain until the required tone is obtained. They are then removed and well washed.

After removing from the fixing bath the prints are well washed in several changes of water, laid in a saturated solution of alum for a few minutes, and again washed.

On removal from the final washing water the prints are squeegeed on to clean plate glass, previously rubbed with French chalk. When dry they are peeled off the glass, and will have a very high polish. For fuller description of this process see **Enamelling.**

If ground glass be used a matt surface is given to the prints, and they resemble an engraving.

For methods of mounting gelatino-chloride prints see **Mounting.**

GENERAL FOG.—See under **Fog.**

GERMAN SILVER.—A triple alloy of copper, nickel, and zinc. The best quality consists of 4 parts copper, 2 parts nickel, and 2 parts zinc. For convenience in working, however, a larger proportion of copper is generally added.

GILDING.—A term sometimes applied to the gold toning process.

GLACIAL ACETIC ACID.—See **Acetic Acid.**

GLAIRE.—See **Albumen.**

GLASS.—A hard, brittle, transparent substance—a combination of silica with some alkali or alkaline earth, such as lime, barytes, etc. Its invention dates from the earliest antiquity. It is certain that the Egyptians carried the art to perfection as early as 3,000 B.C., and most probably earlier. The Assyrians, the Phœnicians, the Greeks, the Etruscans were all acquainted with the manufacture. Benedict Bishop is said to have introduced glass windows into Britain A.D. 674. That country, however, did not distinguish itself for the manufacture of glass until as late as the sixteenth century.

Large quantities of glass are now made in this country, but America imports a large quantity of special kinds. The glass used for dry plates is chiefly imported from England.

There is an infinite variety of glass. The chief of these are green or common bottle glass, broad, spread or sheet window glass, crown glass, plate glass, and flint glass. Special kinds of glass are also manufactured for the production of lenses.

The qualities of glass are its hardness, transparency, homogeneity, strength, and power of resisting the action of water, air, light, and the stronger acids and alkalies.

The principles of glass manufacture are very simple. Silica, in the shape of fine sand, is heated with carbonate of potash, or soda and slacked lime, or oxide of lead. At a high temperature, fusion and combination occur, and carbonic acid is expelled. When the melted mass has become clear and free from air-bubbles, it is left to cool slowly, until it assumes the peculiar tenacious condition suitable for working.

Window Glass is usually made of sand 100 parts, sodium sulphate 40 to 45 parts, chalk or limestone 40 parts, powdered anthracite coal 2 parts, cullet 100 parts, and a small quantity of an oxidizing agent added, such as nitre, arsenious acid, or peroxide of manganese.

Crown Glass is composed of almost the same materials as above, except that a smaller quantity of lime is used, and the materials are, as a rule, more carefully selected. The method by which sheet glass is made is very interesting, and is thus described.* The metal being brought to a workable state and skimmed, a sheet of crown glass is made in this manner: A workman by dipping his long iron blowpipe two or three times into the pot, takes up on the end of it a gathering of about 10 pounds of metal, which, when the pipe is held upright, lengthens by its own weight into a bulb shape (Fig. 202). Rolling this on the marver, the workman makes the outer portion conical, and then by blowing forms it into a pear shape (Fig. 203). Further heating and blowing brings it into the shape of a flattened sphere, and to a much increased size with a point called the bullion point (see Fig. 204). At this stage the glass is transferred from the blowing pipe to an iron rod called a ponty, on the end of which a lump of hot iron metal has been placed. This lump is made to assume the form of a little cup by pressing it on an iron point, and is then pressed against the bullion point of the flattened sphere, to which it becomes firmly attached. The pipe is detached by means of a piece of iron dipped in cold water (Fig. 205). The globe of glass is now held with the ponty. The operator next carries it to the nose-hole and presents the opening formed by the detachment of the blow-pipe to the action of the furnace. This again softens the glass, which is taken to the flashing furnace and kept constantly revolving by turning the ponty on a rest in front of the furnace opening. The revolutions are at first slow, but are gradually accelerated as the softening of the glass goes on, and the centrifugal force so produced throws the edges of the orifice outward, as in Fig. 206. As the glass flattens it is revolved with great rapidity, and advanced so near to the mouth of the furnace as to draw the flames outward, by contracting the draught. This completes the softening of the glass. It then opens suddenly with a rushing noise, caused by the rapid flying outward of the softened glass and the rushing out of the flames. It becomes perfectly flat and of equal thickness (Fig. 207), except at the bullion or centre. The *flashing* is now complete; and after being detached from the ponty it is taken to the annealing oven, into which it is passed through a long horizontal slit which forms the opening, and when fairly in it is dexterously turned on its edge. Here it remains at a temperature somewhat below that required to soften glass until the oven is filled with these *tables* of glass, when the heat is suffered to decline until the whole is cool, when they are removed and are ready for sale.

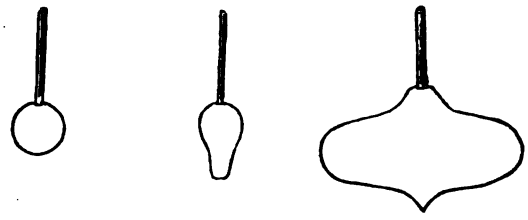


FIG. 202. FIG. 203. FIG. 204.

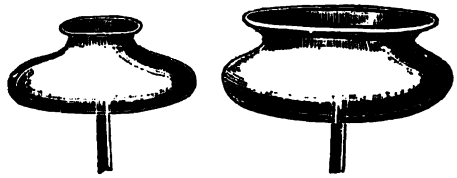


FIG. 205. FIG 206.

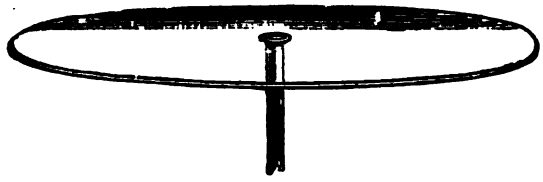


FIG. 207.

Cylinder Glass is made in a different manner to crown glass. The blower first makes a long and perfect cylinder instead of a sphere of glass. By this process much larger sheets can be obtained.

Plate Glass is manufactured by a totally different process to either of the above. In the selection of the materials greater care is taken with regard to their purity. The ingredients, although differing with every manufacturer, may be taken as—Fine sand, 100 pounds; sodium sulphate (refined), 42 pounds; powdered carbon, 2½ pounds; carbonate of lime, 20 to 25 pounds: arsenic, 8 ounces; cullet or broken pieces of plate glass *ad lib.* When these have been melted and the molten metal ready, it is poured on to a flat table, and spread over it with the degree of thickness required. It is then removed to the annealing oven. After the annealing process has been carried out, and the plate cooled, it is removed to the grinding room. Here it is imbedded

* Chamber's Encyclopædia, 1890.

in plaster, and its surface ground by a revolving iron plate set in motion while in contact with the glass. Sand and water first take off the rough surface, and then powdered emery. After one surface has been properly ground, the other is taken in hand and similarly treated. They are then removed to another machine for the polishing process. Here one sheet of glass is made to rub another. The very finest emery powder is used in the final touches given by hand. After both sides have been smoothed in this manner, the plate is placed in another movable machine, where it its brought under the action of the polishers. These consist of padded iron buffers, covered with felt, which rub the glass as it passes from side to side. The surface of the glass is kept supplied with an aqueous solution of oxide of iron in a very fine state of division.

Patent Plate is much used in photographic operations on account of its lightness. It is cylinder glass (selected free from flaws and of good color) ground and polished very much after the same process as employed for plate glass.

Flint Glass.—The following may be taken as the average formula :—Sand, 100; red lead, 66.66; potassium carbonate, 33.33, and a small quantity of peroxide of manganese. In some cases a small portion of the potassium carbonate is replaced by a little refined potassium nitrate. The materials are all carefully selected. Its manufacture is very similar to the other kinds of glass. It possesses a very high power of refracting and dispersing light, owing to its comparatively high density.

Optical Glass is made both of flint and crown glass, lenses being made of both kinds and placed together to obtain achromatism. It must be perfectly homogeneous, free from striæ, colorless and transparent. The operation of making flint or crown glass for the manufacture of lenses is thus described. A crucible is first heated to whiteness in a furnace, and when the fuel ceases to emit smoke, the material is added in small quantities, covering the crucible over each time to prevent the smoke getting into it. After about ten hours' heating it is finished. The crucible is then raised to a white heat for about four hours, and the molten metal continually stirred. The heat is then reduced to allow the bubbles to rise to the surface. After two hours the furnace is again raised to activity and the glass made fluid once more. It is again stirred for about two hours and then left to cool. When cold the crucible is broken away, and the result is a cake of glass, which may be worth pounds or pence according to the number and position of the flaws. If there are many the cake is cut up into smaller discs or slabs, from which lenses are made.

The crown glass used for optical purposes is usually composed of silicates of potash, lime, and alumina. It has a specific gravity of 2.487, and a refractive index of from 1.542 to 1.514. Flint glass for lenses is very difficult to make, especially when required to be of large size. It is generally composed of a mixture of silicates of potash, alum and lead. It has a specific gravity of 3.60, and a refractive index of about 1.639.

The following represent the specific gravity and the refractive index of the optical flint-glass manufactured by the three chief makers :—

	Sp.Gr.	Refraction = D.
Abbe-Schott	3.63	16.206
Feil	3.60	16.169
Chance Bros.	3.60	16.147

These two kinds of glass are chiefly used in the manufacture of lenses for optical instruments, for photographic work, etc., although other kinds have been used. Under **Aberration** can be seen how these two glasses are used in lens making, the defects of one being made to counteract those of the other. (See also **Lens.**)

Toughened Glass.—The discovery of M. de la Bastie. Glass is heated to a point of plasticity and immediately plunged into a heated bath of molten fat, the temperature of which is adjusted to the chemical nature of the glass. Glass treated in this manner is very tough ; it cannot be cut with the diamond, and is not easily breakable ; but when breakage does occur it flies into thousands of pieces.

Colored Glass.—When light falls on a transparent body the body appears colorless, if all the vibrations are transmitted in the proportion in which they exist in the spectrum. If some of the vibrations are checked or extinguished the emergent light will be of the color produced by the co-existence of the unchecked vibrations. Certain metals, when in combination with glass, have the power to effect this. Gold, for instance, even in so small a quantity as the $\frac{1}{100000}$ part will impart a rose color to glass. A crimson glass is made with a compound of glass and tin. A red color from protoxide of copper, and a yellow from oxide of antimony, sesquioxide of iron or carbon ; chloride of silver is also used to stain glass yellow. All these colors can be used for photographic purposes for light for the dark room, &c. A blue glass may be made from oxide of cobalt or copper, and green from sesquioxide of chromium. Colored glass is made either by the color being all through the body or only flashed—a thin veneer of the color coating a clear glass of greater thickness.

For photographic purposes colored glass can easily be made by simply coating a sheet of glass the required size with collodion or gelatine containing the dye color.

Soluble Glass.—See **Soluble Glass.**

Stained Glass.—A transparent effect of color obtained by applying certain metallic oxides to the surface of the glass, and subjecting it to heat. Glass used for dark rooms is usually prepared in this manner. A yellow stain is produced by oxide of silver, and a ruby by cuprous oxide. The stain should be incorporated in the glass, and be as durable as the glass itself.

Opal Glass is made by fusing one of the oxides of tin or zinc with the metal. Flashed opal is made by laying a thin veneer of the opal glass on to a greater thickness of clear glass.

Flexible Glass.—The following formula is given (*Science Illustrée*) for a flexible substance as transparent as glass:

Dissolve four to eight parts of pyroxyline in alcohol and ether in the proportion of a one per cent. solution. Then add two to four per cent. of oil of rice or any other non-siccative oil, and four to ten per cent. of resin or Canada balsam. Coat a plate of glass, and dry in a warm current of air at 50° C. This will give a sheet of a durable, unbreakable, transparent substance impervious to acids and alkalies, and less inflammable than ordinary collodion, and of any desired thickness or color. With zinc oxide it has the appearance of artificial ivory.

GLASS DISHES.—Dishes made of glass. For this purpose it is the most suitable material, owing to its property of resisting acids and other chemicals, which speedily destroy porcelain or ebonite dishes. Its fragile nature is, however, a drawback. Glass dishes are made solid, or can be manufactured by cementing small side strips to a sheet of glass. Good thick glass should be used. The strips are cut to their required length, and their edges ground. These are then cemented to the flat piece with marine glue. To do this they are heated with a spirit lamp and the glue rubbed on while hot. The pieces are then applied together and pressed well into contact with the flat plate.

GLASS HOUSE.—See **Studio**.

GLASS PAPER or **Cloth** is made by powdering glass more or less finely, and sprinkling it over paper or calico still wet with a coating of thin glue. When it is dry the powdered glass adheres firmly, and can then be used for polishing woodwork, etc.

GLASS PLATES.—Glass plays such an important part in photographic operations that a few words with regards to its choice must be given. The different methods of its preparation have been given under **Glass.** It is usually used in sheets or plates. Patent plate is often recommended. It is, however, very expensive, and it must be remembered that this kind of glass, although perfectly flat and having a good polish, does not possess its proper hard surface. This has been ground off in the process of manufacture, and an artificial surface put on. The plate having been denuded of its hard outer skin, will not easily resist the action of acids and chemicals. It has also been found that this glass absorbs impurities. If it be packed with pieces of printed paper between the sheets the glass will often absorb the ink from the type, and a permanent impression, in some cases irremovable by acids, is fixed on the glass, and will reproduce itself on the photographic positives printed from the negative made on the glass.

The difficulty to be experienced with other kinds of glass is their want of flatness, due to the manner in which they are manufactured. Sheet glass, for instance, is true one way, but slightly curved another. For small sized plates this curvature is so slight that it does not make any difference, and the glass has the advantage of a hard surface.

Crown glass usually possesses a double curvature, and its employment for large-sized negatives is to be avoided, because of its liability to crack in the pressure frame. Flatted crown glass, if perfectly flat, is the best kind to use, although a good quality is nearly as costly as patent plate. It has a hard surface, and is, for this reason, superior to plate. It must be noted, however, that only one surface is perfectly flat and smooth, as it is heated and one side flattened on a plain surface, the other becoming by this process slightly irregular.

A good method of testing the evenness of the glass is to hold it in a slanting direction from the eye, and examine the reflection of the sides of the room or any straight lines. If these do not appear quite straight the glass is not perfectly true.

The most important sizes of photographic plates of glass are the following:

2½	inches ×	2½	4	inches ×	5	5	inches ×	7½	11	inches ×	14
2⅜	" ×	2⅝	4¼	" ×	5½	5	" ×	8	14	" ×	17
2½	" ×	4	4¼	" ×	6½	6½	" ×	8½	16	" ×	20
3½	" ×	4	4¾	" ×	6½	8	" ×	10	17	" ×	20
3¼	" ×	4¼	5	" ×	7	10	" ×	12	18	" ×	22
						20 inches × 24					

Air and light both act upon glass, probably by their oxidizing properties. Flint glass, which contains lead, is acted upon by sulphuretted hydrogen, the surface becoming opaque and iridescent. Lenses should therefore, be carefully preserved from the action of sulphur.

GLASS, WRITING ON.—For writing names or labels upon glass bottles hydrofluoric acid is usually employed. Another process recently recommended* is to dissolve 7 grammes potas-

* British Journal Almanac, 1894.

sium sulphate and 36 grammes of fluoride of sodium in 500 c.c. of water and 14 grammes of zinc chloride in another 500 c.c. of water, 65 c.c. of hydrochloric acid being added.

For use, equal parts of the solutions are mixed and the inscription made on the glass with a pen or brush. In about half an hour the lettering will have a matt appearance.

GLAUBER'S SALT.—A name often given to the neutral sulphate of soda (*q.v.*).

GLAZE.—Used in the enamel process (*q.v.*). It usually consists of felspar 27 parts, borax 18, finest siliceous sand 4, nitre, soda, and purest china clay 3 parts. These are heated to a frit mass and 3 parts of calcined borax added.

GLAZING ENAMELS.—See **Enamel Process.**

GLOBE LENS.—A lens invented and first made in America by Messrs. Harrison and Schnitzer, of New York. It is formed of two achromatic and identical convergent meniscus lenses placed so that the external surfaces form one and the same sphere. Fig. 208 shows the construction of the globe lens. It is a symmetrical doublet, and the principal focal point of each combination is at the centre of the arrangement. (See also **Lens.**) It gave pictures free from distortion, but as including rather a wide angle lens was usually faulty from a flare spot in the center. If the lenses had only been placed a little nearer together an even wider angle would have been obtained and the possibility of a flare spot considerably reduced.

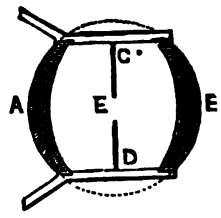


FIG. 208.

GLUCOSE (Synonym, *grape sugar*).—A variety of sugar found in the grape and other fruits. It is occasionally used in photography as a preservative for dry collodion plates.

GLUE.—An impure kind of gelatine (*q. v.*) A large variety of different glues are sold. Russian glue is said to be the purest, and should, when possible, be obtained in preference to the Scotch or English for mounting photographs, as the latter often contains impurities not conducive to the stability of the image.

GLUE, LIQUID.—Many substances go under this name. A good liquid glue can be made by dissolving gelatine in acetic acid, which destroys its setting properties, though retaining its adhesive powers. Another formula is powdered orange shellac, one ounce; alcohol (.805), two fluid ounces. Digest in a stopper bottle placed in a warm situation until the resin is dissolved.

GLYCERINE (Formula $C_3H_5(OH)_3$; molecular weight, 92; synonyms *glycerin, glycerol, prophenyl alcohol*). Discovered by Scheele in 1779. It is a colorless, viscid, neutral, inodorous fluid having a very sweet taste. It is soluble in water and alcohol in all proportions, but insoluble in ether and in chloroform. It should possess a specific gravity of above 1·23. If below this, it is in all probability diluted with water. To ascertain the quantity of water present the following formula is generally used :—

$$P = \frac{1266 - 1000d}{2.66d}$$

Here d is the specific gravity of the sample tested as compared with water, at a temperature of 60° F, and P the percentage of glycerine actually present, provided also that it contains no other matters.

Glycerine occurs ready formed in a few fats, and is always produced in the alcoholic fermentation of sugar; hence it occurs in all fermented liquors.

The usual method of its production for commercial purposes is by distilling fats in a current of superheated steam at 300°, when the fats are decomposed, and the glycerine which distils over is finally rectified *in vacuo*.

A simple method of obtaining it on a small scale is from olive oil, which is saponified by treating it with an equal weight of lead oxide. This is mixed with water and added to the oil, with which it is boiled till the saponification is complete. The glycerine is dissolved by the water and is easily separated from the insoluble lead plaster. Any traces of lead are removed by sulphuretted hydrogen, and the water is expelled *in vacuo*, as the glycerine would turn brown in the air.

The adulterations used in the manufacture of glycerine are glucose and cane sugar. Other matters are often present, such as lead calcium, and formic and oxalic acid, their presence being due to imperfect purification. To detect the presence of glucose, boil a small portion of the sample with an excess of caustic soda and a few drops of copper sulphate. If any be present a red precipitate will be the result. To test for cane sugar boil for half an hour with sulphuric acid. This will convert any cane sugar into glucose, when it can then be tested as described above. Lead and calcium are detected by burning the glycerine, and dissolving the residue in a few drops of nitric acid. The solution thus obtained is then diluted with water and divided into two quantities. Pass sulphuretted hydrogen through one and a black precipitate will show the pres-

ence of lead, and add a small quantity of ammonium oxalate to the other portion, and a white precipitate proves calcium to be present. Oxalic acid is detected by the white precipitate it yields with calcium acetate and formic acid by blackening on warming a diluted sample with ammonio-nitrate of silver.

Glycerine is an antiseptic, and is used in photography principally for this reason. It is used as a preservative of pyro solutions, and is added to gelatine emulsions to prevent decomposition. A small quantity added to water will prevent it freezing, except at a low temperature. It is also used as restraining agent in developing, but its action in this case is purely physical.

Glycerine is extremely hygroscopic, and cannot be dried by heat without decomposition. Its non-drying property causes it to be used for many purposes to prevent too rapid drying of substances. A small quantity is added to gelatine emulsion spread upon paper, which causes the film to become more pliable and less easily cracked. Glycerine burns with a colorless flame, and dissolves iodine.

Table showing strength of solutions of glycerine by specific gravity:—

Glycerine.	Specific Gravity.	Freezing Point C.
%		
10	1·024	1°
20	1·051	2·5°
30	1·075	6°
40	1·105	17·5°
50	1·127	31·34°
60	1·159	Below 35°
70	1·179	
80	1·214	
90	1·232	
100	1·241	

GLYCEROL.—See **Glycerine.**

GLYCIN (Formula $C_6H_4(OH)$, $NH.CH_2$, $CO.OH$. Synonym, *hydroxyphenol glycin.*)—Obtained by the action of chloracetic acid on amidophenol. It takes the form of a light lustrous powder soluble in water in presence of a caustic alkali or alkaline carbonate, forming a colorless solution which can be rendered stable by the addition of a sulphite. It acts as a powerful but slow acting developer, giving clear images of a grayish black color. Potassium bromide acts as a restrainer.

Glycin Potash Developer.

Glycin	5 parts
Crystalized sodium sulphite	15 parts
Potassium carbonate	25 parts
Water	90 parts

For use dilute with 3 to 4 parts of water.

Glycin Soda Developer.

Glycin	3 parts
Sodium sulphite	15 parts
Crystallized sodium carbonate	22 parts
Water	200 parts

Glycin developer may be used with either quinol or eikonogen.

GOLD (Symbol, Au.; atomic weight, 196·85.)—The most widely and universally sought metal in the earth's crust, and too well known to require any description. It is only used in photographic chemistry in combination with other substances. A $10 gold piece weighs 268½ grains, and contains 246 grains of pure gold.

GOLD CHLORIDE.—There are two gold chlorides known to be in existence—aurous chloride (AuCl) and auric chloride ($AuCl_3$). The existence of another gold chloride ($AuCl_2$) called auro-auric chloride has been asserted by some chemists and denied by others. The gold chloride used in photographic operations is the auric chloride, $AuCl_3$; molecular weight, 302.5; synonyms, *terchloride* or *perchloride of gold*, etc. It is formed by dissolving gold in aqua regia (a mixture of nitric and hydrochloric acids) and drying on a porous tile over concentrated sulphuric acid for several days.

A simple method of making gold chloride for photographic purposes is the following:—Mix in a suitable vessel four fluid drachms of nitric acid and two ounces of hydrochloric acid. Into this place a gold coin—the newer the better—and apply a gentle heat. For this purpose a sand or water bath is preferable. A considerable quantity of gas will be evolved, and the gold

will disappear. If the acids are weak, and complete solution of the metal cannot be effected, a little more of the acids mixed in the same proportion should be added. The solution of perchloride of gold in excess of acid thus obtained is next evaporated in a sand or water bath, and the crystals formed are preserved in hermetically-sealed bottles, as they are very deliquescent.

Commercial chloride of gold takes the form of reddish orange needle-like crystals, extremely deliquescent and soluble in alcohol and ether. It is sold in small hermetically-sealed tubes, containing 15 grammes of gold chloride. This weight, however, is no criterion of its value, but the weight of the actual gold contained in it.

Many inferior makes of gold chloride are sold, most of which are, correctly speaking, gold sodio-chloride, with formulæ $AuCl_3$, NaCl, $_2H_2O$.

Nearly every substance which is capable of combining with oxygen or with chlorine tends to reduce the metal from a solution of gold chloride, and it is for this reason that gold chloride is used for the purpose of toning silver prints. For this it is mixed with the soluble salts of free acids, such as the phosphates, acetates, carbonates, etc. The action of the different toning solutions is given by C. J. Leaper in the following equations, assuming in each case that the darkened silver reduction product consists of silver oxychloride ($Ag_2O.2AgCl$.)

1. Sodium acetate.—$15(Ag_2O.2AgCl) + 2AuCl_3) + 6NaH_3C_2$ (Acetic acid.) $= 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl + 6H_4C_2O_3$.

2. Calcium hypochlorite.—$Ag_2O.2AgCl + 2AuCl_3 + 3H_2O$ + (Calcium chlorate.) $CaCl_2O_2 = Ca(ClO_3)_2 + Au_2 + Ag_2 + 2AgCl\ 6HCl$.

3. Sodium pyroborate—$15(Ag_2O\ 2AgCl) + AuCl_3 + 18H_2O$ + (Sodium chlorate.) $3Na_2B_4O_7 = 6NaClO_3 + Au + 15Ag_2 + 30AgCl +$ (Boric acid.) $12H_3BO_3$.

4. Sodium carbonate.—$15(Ag_2O.2AgCl) + 2AuCl_3 + 3H_2O$ $+ 3Na_2CO_3 = 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl +$ (Carbonic acid.) $3H_2CO_3$.

5. Sodium phosphate.—$15(Ag_2O.2AgCl + 2AuCl_3 + 3H_2O$ $+ 3Na_2HPO_4 = 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl +$ (Phosphoric acid.) $3H_3PO_4$.

Gold chloride is very freely soluble in water, giving a yellow solution. It is, however, only feebly soluble in alcohol. To test for salts of gold, note that solutions containing them give the following reactions: A blackish-brown precipitate with sulphuretted hydrogen, and a brownish precipitate with ferrous sulphate or oxalaic acid. A solution of ferrous sulphate is usually employed to precipitate the gold from old or spoilt toning baths.

GOLD HYPOSULPHITE (Formula, $Au_2S_2O_3$; molecular weight, 506; synonym, *sel d'or*).—A salt formed by adding sodium hyposulphite solution to a solution of gold terchloride. It was used in the old Daguerreotype process (*q. v.*) for toning the image. It has recently been recommended for the toning of chloride emulsion papers upon which the image is produced by development. It can be made by adding a 2 per cent. solution of gold chloride (neutral) to a 6 per cent. solution of sodium hyposulphite. If required in crystals mix the solution thus formed with alcohol.

GRADUATE.—See **Measuring Glass.**

GRADUATED BACKGROUND.—See **Background.**

GRAIN.—The unit of weight in the English system. A pound avoirdupois contains 7,000 and a pound troy contains 5,760 grains. (See **Weights and Measures.**) The grain is also the 20th part of a scruple in apothecaries' weight, and a 24th part of a pennyweight troy. A grain is equal to .0647990 gramme.

GRAINED NEGATIVE.—A negative in which the half-tones of the image are broken up into a fine grain. This is usually accomplished by interposing a fine netting, or wire gauze, between the lens and the object photographed. Grained negatives are used in photo-mechanical printing.

GRAMME is the standard unit of French measures of weight, and is the weight of a cubic centimetre of distilled water at 0 deg. centigrade (32 deg. Fahrenheit). It equals 15.42348 grains. The English equivalents for the other French weights corresponding to the number of grammes they contain is easily found thus :—

	Grains Troy.	Grains Avoirdupois.
Centigramme	.1543248	.0000220462
Decigramme	1.543248	.000220462
Gramme	15.43248	.00220462
Decagramme	154.3248	.0220462
Hectogramme	1543.248	.220462
Kilogramme	15432.48	2.20462
Myriagramme	154324.8	22.0462 = .19684 cwt.
Quintal	1543248	220.462 = 1.9684 "

In abbreviating the word gramme Gm. is now generally adopted to distinguish it from gr. or grain.

Gramme Atom.—A quantity of an elementary substance, such that the number of grammes weight is the same as the atomic number of the element—*e.g.*, 40 grammes of calcium (Ca = 40).

Gramme Equivalent.—A number of grammes weight of a substance, elementary or compound, equal numerically to the quantity of that substance, which is chemically equivalent to unit weight of oxygen.

Gramme Molecule.—A quantity of a substance, either elementary or compound, such that the number of grammes and the molecule weight are numerically the same.

GRANULATION.—The process of becoming granular or formed into grains. Zinc and tin may be granulated by pouring the melted metal into cold water.

The term is also applied in photo-mechanical printing to the processes of breaking up the image into a granular state so that the half-tones of the picture may be represented although only one colored ink is used.

GRAPE SUGAR.—See **Sextrose.**

GRAPHITE.—An iron-black mineral commonly known as blacklead, and largely used in the manufacture of pencils. Ground up with diluted negative varnish it gives a dull black coating. Carbon in another form, *i.e.*, lampblack is largely used as a color in carbon printing, and Woodburytype, but usually with some other tint to make the color more agreeable. (See **Lampblack.**)

GRAPHOSCOPE.—An optical apparatus for magnifying photographs or other pictures.

GREEN COPPERAS.—See **Ferrous Sulphate.**

GREEN FOG.—(See **Fog.**)

GREEN GLASS.—Glass colored green has been discovered to be of great service in printing upon chloride of silver paper, such as albumenized paper, etc. It is found that by laying a piece of green glass over the printing-frame, and allowing the light to shine through it before reaching the negative, a far more vigorous print is obtained if a weak negative be employed. The reason of this is that, when the paper is floated on the nitrate bath, two compounds are formed, albuminate and chloride of silver. The silver chloride is insensitive to green light, but the silver albuminate is sensitive. Now the more albuminate of silver contained in the sensitive film, the greater will be the contrast when printing with a weak negative, and if we rob the light from the silver chloride, and allow it to act on albuminate of silver, we obtain the same result. Green glass has this effect by absorbing those rays which have an actinic effect upon the chloride of silver, and allowing those to pass through which will affect the silver albuminate, and by this means much more rapid gradation is obtained, although, of course, the exposure is considerably increased. It also exercises an effect upon the subsequent toning operation. (See **Toning.**)

With a gelatino-citro-chloride paper the same effect, but in a greater degree, is obtained, as the citrate of silver is more sensitive than the chloride. With Aristo papers vigorous prints may be obtained from weak negatives, and from the very weakest by employing green-colored glass.

GREENLAW'S PROCESS.—A modification of the old calotype paper negative process. It is thus described:

Thin negative paper is first selected, quite free from holes and of equal thickness. Then make up a solution of

Potassium iodide	1,000 grains
Potassium bromide	300 grains
Distilled water	40 ounces

Then add enough pure iodine to give the solution a dark claret color. Filter. In a room lighted with yellow light, place as many sheets as required into this solution, care being taken against the formation of air bubbles. Allow the paper to remain in it for about an hour. Then turn the lot upside down and hang the sheets up to dry. The paper thus prepared will keep any length of time. To sensitize prepare:

Silver nitrate	2½ ounces
Glacial acetic acid	2½ ounces
Distilled water	40 ounces

Float a sheet of the iodized paper, smooth side downward, upon this until the purple color of the paper is turned to yellow (silver iodide).

After it has been allowed to rest for about a minute, remove it and immerse in distilled water. Next place it between two sheets of clear blotting paper and remove all superfluous solution, and hang up to dry. When perfectly dry, the paper may be exposed in the camera in the ordinary manner. Prepare:

Gallic acid	200 grains
Spirit of camphor	1 drachm
Distilled water	40 ounces

and, previous to development, add to every 5 ounces of the solution:

Silver nitrate	30 grains.
Glacial acetic acid	½ drachm
Distilled water	1 ounce

Pour quickly into a shallow dish, and float the picture side of the paper upon it. The image will be slightly visible, so no difficulty will be experienced in detecting the exposed side. Watch carefully until the image is visible on the back, and continue the development until, in holding up a corner, where the sky of the picture is, before the light, you cannot see the finger if moved about between the light and the paper. If the image be insufficiently developed before the silver gallate decomposes, it is under-exposed. As soon as the silver gallate is decomposed it ceases to develop.

A more convenient method of developing is by brushing the solution over the paper previously wetted with water.

After development the negative is well washed, and fixed by placing it in a solution of sodium hyposulphite, 1½ ounces to 1 pint of water, until all yellow silver iodide disappears. After this it is well washed in many changes of water, and a clear, fine, and dense negative is the result.

GREEN PAPER.—An albumenized paper can be obtained of a slight greenish tint. It is often preferred for printing landscape negatives.

GREEN PICTURES.—Obtained by floating paper on a 60-grain solution of uranium nitrate, and exposing for about ten minutes under a negative. Hardly any effect is visible until the paper is washed and brushed over with a weak solution of potassium ferrid-cyanide, which will develop a red image. Whilst still moist it is immersed in a solution of sesquichloride of iron (10 grains to the ounce), and the tone will soon change to a bright green.

GREEN SPOTS.—These sometimes make their appearance in prints, and are due to the presence of small particles of inorganic matter in the paper.

GREEN VITRIOL.—(See **Ferrous Sulphate.**)

GROUND GLASS.—Glass which has been ground on one or both surfaces. Its principal use in photography is for the focusing screen of the camera. (See **Focusing Screen.**)

It can easily be manufactured by rubbing two pieces together and sprinkling between the two surfaces some fine emery powder and water.

Ground glass is also used for backing transparencies, and for many other purposes where the light is required to be diffused, as in the studio skylight, but for this a substitute is usually employed. (See **Studio.**)

GROUND GLASS PLATES.—Dry plates used principally for making positive transparencies. The emulsion is spread upon ground glass instead of plain, and this obviates the necessity of framing a piece of ground glass with the picture, a protective glass only being required.

GROUP.—In art, the term is used to signify the union of several figures, or of various material objects, placed in contact with each other for the purpose of forming a single group. Robinson, in his "Pictorial Effect in Photography," says: "The great art in the composition of a group is in so arranging the figures that they shall have some relation to each other, as well as the ordinary elements of pictorial construction. There should be some bond of union between those who compose the group, some incident should be represented in which they are mutually interested, or something must be imagined out of the picture to attract the attention of both, if only two are represented, or of many of them if there is a number. The figures should be massed together, and not scattered over the picture, so as to make it necessary to examine each portrait in detail, until it has been seen and the effect agreeably felt as a whole. . . . When the picture is larger than *carte de visite* or cabinet size, it is always better

and much easier to produce a group by combination printing. To accomplish this, a sketch should be made of the composition, no matter how roughly done, so that the artist knows what is intended by it, or the figures may be placed in position, and a small photograph taken of the arrangement. They should be so grouped that the joining should come in unimportant places. When a sketch or small photograph is made, the groups or single figures should be photographed in detail by preference against a white or very light screen if a background is also to be put in."

GUAIACOL (Formula, C_6H_4. OH. OCH_3; synonym, *methylpyrocatechin* or *methylcatechol*).—Obtained by distilling *guaiacum*, a resinous exudation from the West Indian tree *Lignum vitæ*. It is a colorless aromatic liquid, sp. gr. 1·12, boiling point 200°C., miscible sparingly in water, and easily in alcohol. It has rather a pungent smell.

Guaiacol has recently been recommended by Colonel Waterhouse as a preferable developer to pyrocatechin, on account of its being a much cheaper product. 25 to 30 minims of it are dissolved in a 4 per cent. solution of sodium carbonate (crystals). This acts as a fairly rapid developer for dry plates. The deposit is even and fine grained, of a yellowish brown tint, but with good printing powers.

GUM ARABIC.—A gummy exudation from the various species of acacia, principally, however, from the *Acacia senegal*, a tree of some twenty feet high, growing abundantly in West Africa. It occurs in irregular lumps, odourless, soluble in cold water, and very rapidly in boiling water, forming a clear, viscid, adhesive solution, and in this form is used as an adhesive agent. Gum arabic is insoluble in alcohol, ether and oils. It makes a good mountant. The addition of a little salicylic acid will preserve it for a great length of time. If aluminium sulphate be added its adhesiveness is increased.

It is also employed in photography in the powder process, and in photo-lithography owing to the fact that when mixed with potassium bichromate its solubility decreases with the action of light.

GUM DAMMAR.—See **Dammar.**

GUM DRAGON.—See **Gum Tragacanth.**

GUM ELEMI.—See **Elemi.**

GUM GALLIC PROCESS.—An old process, in which the plate was edged with albumen, coated with iodized collodion, and immersed in the nitrate bath for a few minutes. It was then well washed and flowed over with a solution containing gum arabic, sugar candy, and gallic acid. The plate was then drained and dried. The exposure necessary was from four to twenty times that required for a wet plate.

GUM GUAIACUM.—A resinous exudation from a lofty tree named the *Guaiacum officinale*, which grows in St. Domingo and Jamaica. It is soluble in absolute alcohol to the extent of 90 per cent. If triturated with water it forms a pale greenish mucilage. It is slightly sensitive to light, and was used by Niepce in his experiments in photo-lithography: It was also used as a preservative in the collodion process. (See **Preservative.**)

GUM PROCESS —An unused dry collodion process, in which gum arabic is the preservative. A trace of free nitrate is left upon the sensitive plate, along with the solution of gum. The exposure is the same as for wet plates, and the development is the old way, with acid pyrogallo-nitrate of silver.

GUM PROCESS.—A process used in photo-lithography (*q. v.*)

GUM TRAGACANTH.—Obtained from the *Sterculia tragacantha* of Sierra Leone, and the *Astragalus verus* of Asia Minor. It should be nearly white, but is usually of a slightly reddish color. If plunged in water it dissolves in part, swells, and forms a thick mucilage. Boiling water will dissolve it much more readily, as will also alcohol.

GUN COTTON.—See **Pyroxyline.**

GUTTA PERCHA.—A substance similar to caoutchouc. It is the dried milky juice of the various trees of the order *Sapotaceæ*, the chief being the lofty forest tree, the *Isonandra gutta*, a native of the Malayan Archipelago.

Gutta percha is an extremely useful substance because of its property of resisting the action of cold water and damp. It is not acted on by alkalies, and many of the strongest acids. Hydrofluoric acid, which dissolves glass, may be kept with safety in vessels made of this substance.

It may be softened by hot water, and pressed into various forms, it becoming hard when cool. Only a small portion of it is soluble in absolute alcohol and ether. Benzol and spirits also partially dissolve it. Sulphide of carbon and chloroform, however, completely dissolve it.

A process has been patented by which gutta percha can be vulcanized with sulphur, and in this state it can be made to have a hard glazed surface.

It was formerly much used for making baths and dippers for the collodion process. A good cement for gutta percha articles is made as follows:—

Carbon bisulphide	5 ozs.
Gutta percha	10 drams.
Indiarubber	5 drams.
Fish glue	25 drams.

HALATION.—Sometimes called Irridiation. A term used to express a curious effect, often observable in photographic negatives, *i.e.*, the spreading of light beyond its proper boundaries, the high lights encroaching upon the surrounding shadows, or darker portions, producing local fog This effect is very often met with in photographic interiors in which are windows facing the sky, and sometimes in landscape pictures, especially during autumn and winter, when the bare tree branches stand out against the sky. These are fogged in the negative, all the fine detail being lost. The defect is also visible if a plate be exposed in the direction of the sun and the direct rays enter the lens. There are two or three causes of halation; the principal one, however, is the reflection of the light from the back surface of the glass plate. Abney, in his "Instruction in Photography," gives a very good explanation of the effect of halation, the result of very careful investigations. He says: "Rays of light entering a film are scattered by the particles of silver salt, and obey certain well-known optical laws. Suppose S″ (Fig. 209) to be a magnified image of a grain of the silver salt lying on the glass plate. Let A, B, and C be three of the rays falling on S″. They will each be reflected according to the ordinary laws of reflection. A, which falls on the top of the grain, will be reflected vertically back; B will be reflected to m, the top surface of the glass, and be refracted to n, and will be totally reflected from n to o, where another particle (S) may be situated; B, by reflection, will then act on S. The ray C will be reflected immediately between S″ and S′ to p, and will be refracted to q. Part will pass out to t, and part be reflected to Y, where another grain of silver (S′) may be situated, and therefore the ray C will also act on S′, as well as on S. This will be the case, although no direct rays fall on S′ and S. More rays are reflected back at what is known as the critical angle of the glass than any other part. Thus a dot will be surrounded by a circle of great intensity, shading off towards the center and to the outside (Fig. 210). A line will show a halo, as in Fig. 211, and this can be built up of a series of circles (Fig. 212). A cross can then be traced to the figures surrounding two lines at right angles (Fig. 213). Again, by increasing the thickness of the plate, the figure is seen to be extended (Fig. 214), as should be the case as required by theory.

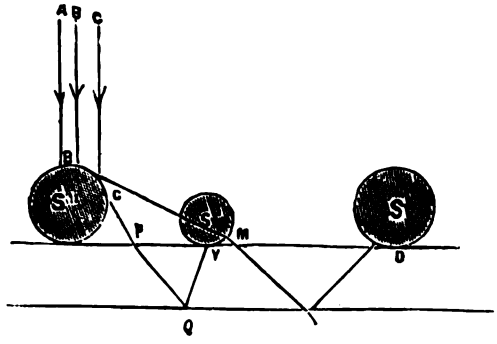


FIG. 209.

FIG. 210

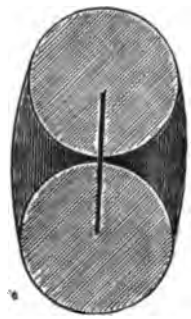


FIG. 211.

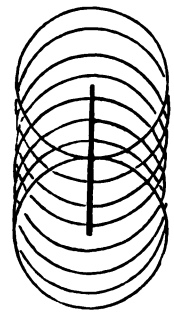


FIG. 212.

The image of a disc will be surrounded by a halo encroaching up to its edge, as shown in Fig. 215, and this again can be shown to be built of a series of circles formed by every point in the disc, as can the image of a triangle (Fig. 216).

In Eder's "Handbuch" the following concerning halation is given: "Halation is usually produced by the reflection of a portion of an incident ray from the under surface of the glass plate.*

Let us consider a simple case. If a ray of light A B (Fig. 217) falls upon the glass plate M N O P (by placing a piece of perforated tinfoil upon the plate and exposing without a lens), this ray is broken, and takes the direction B C to the back part of the plate. At C part issue from the plate and part is reflected back on to the sensitive film at D. This reflection may take place several times, as shown in Fig. 218. O C is the incident ray. A portion is reflected in the direction of 1, and part penetrates the glass, here it partly escapes to a, and partly becomes reflected at d. It now diverges in the direction 2,

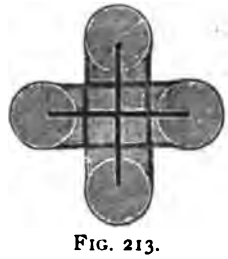


FIG. 213.

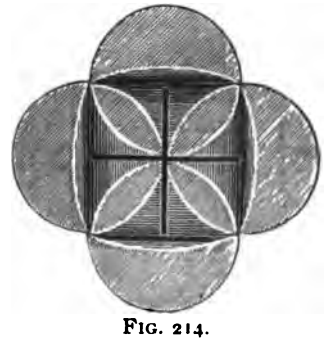


FIG. 214.

* The rays of light, after passing through the bromide emulsion film, are still sufficiently actinic as to cause an effect after being reflected from the back of the glass plate. It is possible to place behind the dry plate in the camera a second one, and develop a picture upon it.—EDER.

and is partly reflected along 5, the process being repeated several times. If the glass is held at a certain angle towards a shining light it is possible to see the secondary images by looking in the direction of the arrows 8 to 13.

In photographic practice, however, this effect does not take place, as the semi-transparent emulsion film diffuses the light. The rays which strike point B (Fig. 219) do not all follow the line B C, as would be the case were they passing through clear glass, but are partly reflected in the directions C D, etc., according to the principles of refraction.

Fig. 215.

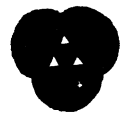


Fig. 216.

This explains the halo which surrounds the bright parts.

As this defect generally proceeds from the reflection of the glass, it is obvious that by substituting paper or card for the glass support we should partly prevent its occurrence. Thus gelatine or celluloid negative films will give this defect, but only in a very slight degree, owing to the thinness of the support. Halation can also be to a certain extent prevented by making the film opaque, and thus prevent the light from passing through it. The amount of opacity necessary must be regulated by the brightness of the subject to be photographed, and the duration of the exposure necessary. Matt surface plates, thickly coated with an emulsion containing iodide, as well as bromide, the iodide being much more opaque than the bromide, will therefore prevent the light passing readily through to cause halation. If, however, iodide cannot be added the film may be colored with one of the red or yellow coal-tar dyes.

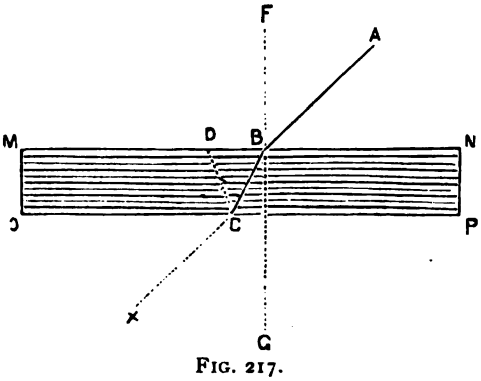


Fig. 217.

Another method is to back the glass with some kind of "backing" which will reduce the amount of reflection. For the different methods see **Backing.**

In photographing interiors, it is often a good plan to cover the windows with a slightly opaque substance, such as unbleached calico. This will effectually reduce the intensity of the light. Some operators hang small strips of black velvet in front of the camera during exposure in such a position that they will block out the windows in the image. Before the completion of the exposure, however, they are removed for a short time.

Up to the present we have only considered halation which proceeds from the reflection of the glass. But this defect will also make its appearance at times even if the sensitized film be mounted on a perfectly opaque support. The cause of this is not known with certainty, but it is generally believed to be due to the billions of tiny motes we see so clearly in the air when a beam of strong light passes through it. These little motes all reflect light, and it is possible that those contained in the camera scatter the light coming through the lens in all directions, and thus produce fog. The defect when resulting from this cause is usually, however, so slight as to be hardly worth troubling about.

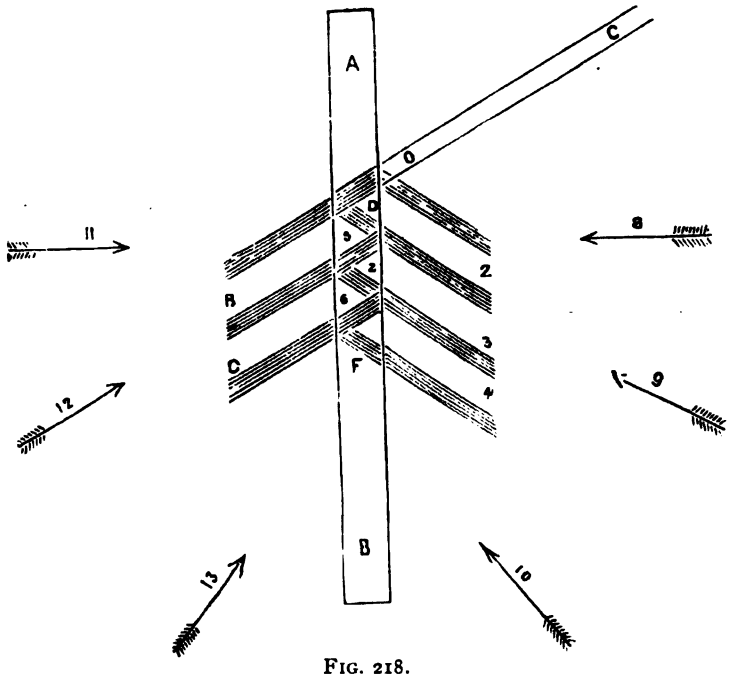


Fig. 218.

Halation may be due to the lens itself, which is a source of scattered light, as photographic lenses are rarely polished to perfection. The imperfections are easily seen if one holds the lens between the eye and bright gas flame and moves it sideways until the flame becomes invisible. The lens now has the appearance of being luminous, and the irregularities of its surface will often reflect the light in stray directions in a very similar manner to the motes in the camera.

HALF-PLATE.—A photographic size, 6½ x 4¼. The half of a whole plate would be 6½ x 4¼.

HALF-TONE.—The shades of color between the black and white of the image are termed half-tones. In reproduction processes, in which one colored ink is employed, the half-tones are represented by fine dots or stipple. (See **Photo-Mechanical Processes.**)

HALF-TONE PROCESS.=See **Photo-Engraving.**

HALF-TONE SCREEN.—A sheet of glass ruled with fine lines and used in the half-tone process of photo-engraving (q.v.).

HALO.—See **Halation.**

HALOGEN.—The electro-negative radical of a haloid salt. The term is also applied to chlorine, bromine, iodine, and fluorine from their tendency to produce salts resembling sea-salts in their composition. These elements are also termed salt radicals from their property of forming salts by direct union with the metals.

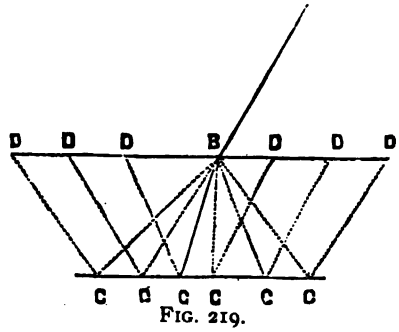


FIG. 219.

HALOID SALTS.—A name given to salts formed by the combination of a halogen element with a metal, or the union of a radical which does not contain oxygen with a metal Sodium chloride, cadmium bromide, potassium iodide, etc., are haloid salts.

HAND CAMERA.—A small camera capable of being held in the hand when exposing. (See **Camera.**)

HARDENER.—Gelatine negatives and papers are particularly sensitive to moisture and warmth. In working in hot summer weather, unless ice be employed, the film will dissolve. For this reason hardeners or hardening solutions are employed. Potash alum, chrome alum, sulphites, and other substances have the effect of hardening gelatine and causing it to withstand heat even when in a moist state. A good form of hardening solution is the following:

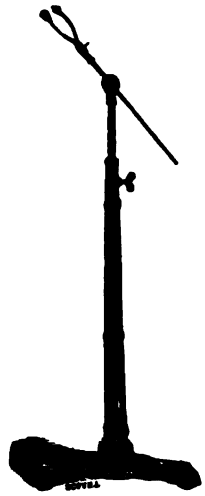
Water	1 quart
Sulphite of sodium	4 ounces
Chrome alum	2 ounces

This, with the addition of one-half ounce of sulphuric acid, can be mixed with the fixing bath and the negatives or gelatine prints fixed and hardened at the same time. For other hardeners see **Gelatine.**

HAT CAMERA.—A small camera concealed in the hat with the lens only protruding.

HEAD REST.—An apparatus used in portrait photography to keep the head steadily in position during the exposure. (Fig. 220). With the present rapid plates this is hardly ever necessary, except with very nervous sitters. It is usually made of iron, the base being very heavy, to obtain firmness. If used, it should be brought gently to the sitter's head, so as to give sufficient support without being used as an instrument of torture. It must be arranged behind the sitter in such a manner that no part is visible in the picture.

Several kinds of head-rests have recently been manufactured, which can be fitted on to the back of the chair upon which the sitter is, and used in that position.


HEAD-REST.
FIG. 220.

HECTOGRAMME.—A French weight or measure containing 100 grammes, or 3.215 ounces troy.

HECTOLITRE.—A French measure of capacity for liquids, containing 100 litres = $\frac{1}{10}$ of a cubic metre, or 22.009668 imperial gallons; as a dry measure it contains 10 decalitres, or about $2\frac{5}{8}$ Winchester bushels.

HECTOMETRE.—A French measure of length containing 100 metres = 109.3633 yards.

HELIOCHROME.—A name given by Niepce to the products of his process of photography in natural colors.

HELIOCHROMY.—A name given to the process of making photographs in natural colors, as yet a long way from perfect. As far back as 1848 naturally colored photographs were obtained. But these are, however, fleeting, and fade away instantly the pictures are exposed to bright light. Many clever and persevering experimentalists have endeavored to perfect a process by which a lasting image could be formed precisely the same in color to the image formed by the lens upon the ground-glass screen of the camera. Among the scientists may be mentioned Dr. Seebeck, of Jena, Sir John Herschel, Robert Hunt, Poitevin, Becquerel, Carey Lea, and Abney, none of whom, however, succeeded in obtaining satisfactory results.

It is probable that the French physicist, Edmond Becquerel, produced the most successful photographs of color. The following is his method*: Taking a silver plate, such as is used in

* "History of Photography," by W. J. Harrison, F.G.S.

Daguerreotype, he obtained a thin and very uniform coating of silver chloride on its surface. This he sometimes effected by soaking it in chlorine water until the silver assumed a rose tint, or by dipping it into solutions of cupric or ferric chloride. By preference, however, he placed the silver plate in a solution of hydrochloric acid, and attached to it a wire from the positive pole of a voltaic battery, the wire from the negative pole being fastened to a plate of platinum which also dipped into the acid solution. By this means the hydrochloric acid was decomposed, and the chlorine being drawn by electrical attraction to the silver plate, combined with it chemically, forming a surface of silver chloride of great purity. As the combination of its silver and chlorine took place, the layer of silver chloride gradually increased in thickness, and as it did so color changed to gray, yellow, violet, blue, and continuing the action, these colors appeared a second time. When the second violet tint had been obtained the silver plate was withdrawn from the solution, washed and dried, and gently heated until the surface assumed a rosy hue. When the spectrum of sunlight or of the electric arc was received upon a plate so prepared, an exposure of a few minutes was sufficient to impress the diverse colors. Images of highly-colored dressed dolls were also obtained.

Abney is of opinion that these colors obtained by Becquerel upon Daguerreotype plates are due to the oxidation of the silver compounds employed. When the sensitive plates are exposed in the presence of an oxidizing agent, as by dipping them into peroxide of hydrogen before or during exposure, the colors are more readily produced.

At a recent meeting of the French Photographic Society M. Vallot described his process of photography in colors, the same being a modification of that of Poitevin.

A strong photographic paper (Rive's 12 kilos., answers admirably) is floated five minutes on—

Water	100 parts
Sodium chloride	10 parts

and dried as rapidly as possible.

When dry the paper is sensitized on—

Distilled water	100 parts
Silver nitrate	20 parts

It is then drained for a few seconds, and washed in distilled water, and afterwards for ten minutes in running water; finally, to thoroughly eliminate all traces of free silver, the paper is placed for five minutes in a bath of—

Water	1000 parts
Sodium chloride	20 parts

After leaving this bath the sheets are well washed in running water and laid while moist, sensitive side under, on a bath containing 500 hundred parts of water, to which 20 parts of the following solution have been added—

Distilled water	100 parts
Protochloride of tin	5 parts
Sulphuric acid	2 drops

The whole is then exposed to diffused light to transform the white silver chloride into violet sub-chloride.

After washing, the paper is then dried in the dark, and afterwards laid in a mixture of equal parts of the following solution :—

SOLUTION 1.

Potassium bichromate	5 parts
Water	100 parts

SOLUTION 2

Saturated solution of copper sulphate.

The exposure required is about three-quarters of an hour to strong sunlight.

After exposure the colors are already perceptible. The paper is then plunged into—

Water	1000 parts
Sulphuric acid	20 parts

It will be seen, therefore, that the production of colored images is not altogether impossible, as it has already been achieved. These colored images are, however, far from being perfectly true to the natural colors of the object photographed; some of the tints are entirely missing, whilst others are represented by colors certainly not natural, the whole being a very poor imitation of the glorious tints of nature.

Another serious difficulty confronts the experimenter. These colored images obtained, how can they be fixed? As yet no method has been discovered, and heliochromy, or photography in natural colors, still remains the dream of the future.

HELIOGRAPH.—A combined astronomical and photographic instrument used for obtaining photographs of the sun. A picture made by the process of heliography.

HELIOGRAPHY.—Another name for photography. Niepce also gave this term to one of his processes of obtaining bituminous images upon polished metal plates.

HELIOPHOTOGRAPHY.—See **Nomenclature.**

HELIOSTAT.—See **Heliograph** (first definition).

HELIOTYPE.—A modification of the collotype process, the principal feature being that the gelatine film can be hardened with chrome alum and afterwards detached from the support upon which it is first prepared. It thus forms a tough and flexible skin of gelatine, which can be used at any time for printing from by attaching to a zinc plate or to a cylinder.

HELLENOTYPE,—See **Ivorytype.**

HIGH LIGHTS.—A photographic term applied to the brightest parts of a positive picture. In the negative these portions possess the greatest density or opacity.

HILLOTYPE.—This was the name given to an imaginary process discovered by a hypocritical American preacher. The process was said to produce photographs "glowing with all the glorious colors of nature." A large sum of money was advanced the "discoverer" for the details of his process, which was found to be a fraud.

HISTORY OF PHOTOGRAPHY.—See **Photography.**

HOLDERS.—See **Plate-holder, Slide-holder,** etc.

HONEY PROCESS.—A collodion dry-plate process independently proposed by George Shadbolt and Maxwell Lyte about the year 1854. The principle of the process was the use of a solution of honey or of grape sugar to coat the sensitized plate, previously washed, until the greater portion of the free silver nitrate had been removed.

Previous to the development the honey was washed away and the plate again dipped in the nitrate bath. The object of coating with honey was to keep the surface moist and prevent crystallization of the remaining silver nitrate. Double the exposure of wet plates was, however, necessary.

HORN SILVER.—If white silver chloride be dried in the dark and heated in a crucible, it fuses at 451 deg. C. to a brownish liquid, which solidifies on cooling to a transparent, almost colorless mass, somewhat resembling horn, and for this reason called by the alchemists "*luna cornea*," or "horn silver." Fabricius was the first to discover its properties of becoming black on exposure to light. He describes the discovery in his Book on Metals published in 1556. Strong heat will convert it into vapor, but will not decompose it.

HUSNIK'S PROCESS.—See **Leimtype.**

HYDRIC IODIDE.—See **Hydriodic Acid.**

HYDRIC SULPHATE.—See **Sulphuric Acid.**

HYDRIC SULPHIDE.—See **Sulphuretted Hydrogen.**

HYDRIC SULPHITE.—See **Sulphurous Acid.**

HYDRIODIC ACID (Formula. HI; synonyms, *iohydric acid, hydric iodide, hydrogen iodide*).—Iodine vapor combines with hydrogen under the influence of heated platinum to form hydriodic acid. It is a colorless gas condensed to a liquid by a pressure of four atmospheres at o deg. It is very soluble in water.

HYDRO.—A prefix derived from the Latinized form of Gr. *hudro*, the form in which *hudor* =water. Before a vowel it is sometimes changed to *hydr*. In chemistry this prefix is used to denote that the acid contains no oxygen, it being a combination of hydrogen with a non-metallic element as HCl, hydrochloric acid, or with a radical as HCN, hydrocyanic acid.

HYDROBROMIC ACID (Formula, HBr; molecular weight, 80.75; synonyms, *bromhydric acid, hydrogen bromide*).—A colorless gas with a pungent acid, very irritating odor, which dissolves largely in water.

An aqueous solution of hydrobromic forms a colorless liquid. The amount of acid contained in it can be ascertained by the following table of its specific gravity compiled by weight.

Specific gravity of 15 degrees C.	Percentage of pure hydrobromic acid.
1.080	10.4
1.190	23.5
1.248	30.0
1.385	40.8
1.475	48.5
1.515	49.8

Samples of hydrobromic acid sometimes contain a little iodide. This may be detected by adding a small quantity of starch paste and a little bromine to it. If iodide be present, a blue color will be visible. It can be purified by re-distilling over potassium bromide.

Aqueous solutions of hydrobromic acid are decomposed by most metals, with formation of metallic bromide and hydrogen. Its use in photography is mainly confined to the production of certain bromides.

HYDROCARBONS.—A series of compounds, consisting of carbon and hydrogen only, produced chiefly by the natural or artificial decomposition of organic substances. Among those best known may be mentioned paraffin, benzine, turpentine.

HYDROCHLORATE OF AMMONIA.—See **Ammonium Chloride.**

HYDROCHLORIC ACID (Formula, HCl; molecule weight, 36.5; synonyms, *chlorhydric acid, hydrogen chloride, muriatic acid, spirits of salts*).—This acid is found in nature among the gases emanating from the active volcanoes, and occasionally in the spring and river waters which take their rise in volcanic districts, especially in South America. It is produced artificially by warming together common salt and strong sulphuric acid :

Common salt.		Sulphuric acid.		Hydro sodium sulphate.		Hydrochloric acid.
$2NaCl$	+	H_2SO_4	—	Na_2SO_4	+	$2HCl$

the sodium of the common salt changing place with the hydrogen of the sulphuric acid. The hydrochloric acid escapes as a colorless gas with a most irritating acrid odor. It is very soluble in water, and in this form it is sold as "spirits of salts," hydrochloric acid, or muriatic acid. The most concentrated solution has a specific gravity of 15 deg. C. of 1.214 and contains 143.09 per cent. of the gas.

The solution commonly sold is, however, weaker, having a specific gravity of from 1.12 to 1.15, and contains about 24 or 30 per cent. of real acid.

Specific gravity at 15 deg. C.	Percentage of pure hydrochloric acid.	Specific gravity at 15 deg. C.	Percentage of pure hydrochloric acid.
1.0103	2.22	1.1504	29.72
1.0189	3.80	1.1588	31.50
1.0310	6.26	1.1730	34.24
1.0557	11.02	1.1844	36.63
1.0751	15.20	1.1938	38.67
1.0942	18.67	1.2021	40.51
1.1048	20.91	1.2074	41.72
1.1196	23.72	1.2124	43.09
1.1308	25.96		

Hydrochloric acid becomes weaker by heating, as it rapidly volatilizes at boiling point of water. The pure acid should be quite colorless and free from perchloride of iron or organic matter. Free chlorine and sulphuric acid are also sometimes present. Chlorine may be detected by adding a drop or two of the solution to a mixture of starch paste and potassium iodide; if present, a blue color will be obtained. Absence of sulphuric acid may be proved by diluting the hydrochloric acid with six times its volume of water, and adding barium nitrate, no precipitate should be formed.

For photographic purposes this acid should be used as pure as possible. It must be preserved in closely stoppered bottles, kept covered from too strong light, because light decomposes it, and gives free chlorine. It is used in photography for dissolving out ferric oxalate from platinotype, bromide prints, etc., acting as a clearing solution. It is also used in the preparation of various chlorides.

HYDROFLUORIC ACID (Formula, HF; molecular weight, 20; synonyms, *fluorhydric acid, hydrogen fluoride*).—An acid obtainable either in liquid or gaseous form. It is prepared by decomposing calcium fluoride by sulphuric acid, and by heating acid potassium fluoride.

Its chief use is in etching glass, as it decomposes and dissolves silicates. Glass, being a complex silicate, is readily attacked by the acid, tetrafluoride being formed. The liquid acid etches glass bright, and is used for producing bright designs on ground glass. The gaseous acid etches it with a dull appearance, and is used for producing matt designs upon bright-surfaced glass. The glass is covered with a thin coating of wax, and the design traced through the wax

down to the glass with a sharp-pointed instrument. It is then treated with the acid, which etches the exposed parts. By this means the names of the contents of bottles can be written on the glass, the same being perfectly ineffaceable.

This action of the acid upon glass causes it to be used in photography for stripping gelatine films from the glass. When working with it, however, it must be remembered that porcelain or glass dishes cannot be safely used unless coated with beeswax. Dishes made of guttapercha will resist the strongest acid. Vessels to contain the acid are also made of this substance, as glass bottles cannot be employed.

HYDROGEN.—An important elementary substance, one of the elements of water, and contained in all vegetable and animal products. It may be obtained by passing the vapor of water over red hot iron filings. The change that takes place may thus be represented—

$$3Fe+4H_2O=Fe_3O_4+H_2$$

It may also be produced by submitting water to the action of an electric current, by which the elements, hydrogen and oxygen, of which it is composed, are separated. Pure hydrogen is a colorless gas, without taste or odor. It burns readily in the air, combining with the oxygen to form water. Its flame is very slightly luminous, but of intense heat.

Perhaps the simplest method of preparing hydrogen gas in small quantities is given in the following description:*

Hydrogen gas is generated by the action of dilute sulphuric acid on metal. Zinc is the best for our purpose.

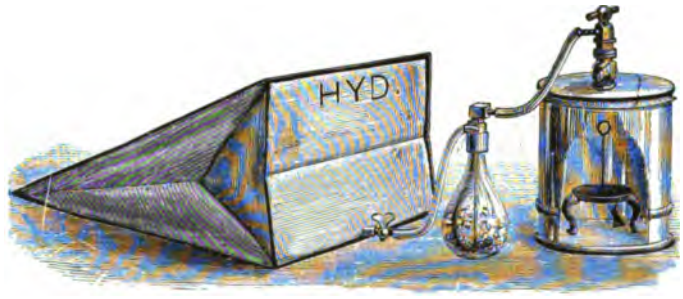
The generator consists of a vessel (of some material not readily affected by the acid) having suspended inside of it a bell, the lower large end of which surrounds a lead cup. The lead cup holds the pieces of zinc.

We prefer to use glass vessels ordinarily. The outer vessel is covered with a brass cap, through the center of which passes a tube. To the inner end of the tube the small end of the bell is cemented, and is by that means suspended inside the outer vessel. By the outer end of the tube connection by means of rubber hose is made with the purifying bottle. The hose is attached to that tube in the bottle, which extends inside nearly to the bottom. From the other tube or outlet of purifying bottle connection is made by means of another rubber hose with the bag.

The purifying bottle must contain water enough to cover at least an inch of lower end of the tube.

Nearly fill the lead cup in generator with pieces of zinc. Free the bags and tubes from air by pressure and blowing.

Pour the dilute acid into generator. Close the stop cock in outlet tube and place the cover and bell. Before making the final connections allow some gas to escape as you make each connection, that a free passage may be assured.



GAS BAG. WASH BOTTLE. GENERATOR.

FIG. 221.—APPARATUS FOR MAKING HYDROGEN GAS.

One part of sulphuric acid to six parts of water is about right for the solution. As this solution will be hot when it is first made it should be allowed to cool before it is poured into the generator, simply as a precaution against breakage or damage to the generator. Of course, if no other glass or earthen vessel is convenient the solution may be made in the outer vessel of the generator and allowed to cool for an hour or two before the zinc is put in or the cover placed.

As the fumes from this operation are disagreeable, it should be done out of doors, or at least at an open window.

The heat spoken of above is generated by chemical action, and it must not be supposed that artificial heat is in any way required for the making of this gas.

Hydrogen is the lightest substance known, being about 14½ times lighter than air, and having a specific gravity of 0.693. Owing to its characteristic lightness, it is taken as the standard of unity in referring to the atomic weight of bodies. Two volumes of hydrogen with six of air form an explosive mixture. Hydrogen is only but slightly soluble in water, nor is any other liquid capable of dissolving it in great percentage. It can be liquefied by exposing it to a pressure of 650 atmospheres and a temperature of 140 deg. C. It, however, remains liquid at 320 atmospheres pressure, the temperature remaining the same. It unites with all other elementary gaseous bodies to form a large number of important compounds.

*This description is furnished by Messrs. J. B. Colt & Co., 16 Beekman Street, New York, who supply the apparatus depicted.

HYDROGEN BROMIDE.—See **Hydrobromic Acid.**

HYDROGEN CHLORIDE.—See **Hydrochloric Acid.**

HYDROGEN DIOXIDE.—See **Hydrogen Peroxide.**

HYDROGEN FLUORIDE.—See **Hydrofluoric Acid.**

HYDROGEN IODIDE.—See **Hydriodic Acid.**

HYDROGEN PEROXIDE (Formula, H_2O_2; synonyms, *peroxide of hydrogen, hydrogen dioxide hydroxyl, oxygenated water*).—A colorless liquid, either neutral or faintly acid, prepared by decomposing barium dioxide by dilute acids. The presence of a little free acid renders it more stable, and it is usually sold with the addition of a small quantity of hydrochloric acid. Its uses in photography are not numerous. It has been recommended as an eliminator of the sodium hyposulphite, which it converts into a salt of one or more of the higher sulphuric acids. A very weak solution, about one dram to four ounces, must be used, however, otherwise the tones of the prints will be reduced and sulphur deposited. It is principally used as a test for iodine when combined with chlorides or bromides, owing to its action of liberating the iodine from its metallic compounds without affecting either the bromides or the chlorides.

HYDROGEN POTASSIUM TARTRATE.—See **Cream of Tartar.**

HYDROMETER OR AREOMETER.—An instrument for determining the specific gravities or relative densities of liquids. The principle upon which it works is that when a body floats on a liquid, and thus displaces a quantity of the liquid, the weight of the solid body is equal to the weight of the liquid which it displaces. The density of the liquid is determined either by the depth to which the hydrometer sinks in the liquid, or by the weights required to cause it to sink to a certain depth. With both kinds, however, correction must be made for variations in temperature.

HYDROMETER
FIG. 222.

Baume's Hydrometer is largely employed on the Continent. It consists of two diffrenet instruments, one for liquids heavier than water, and one for those which are lighter. The first floats at the zero point, in distilled water, at a temperature of 58° F., and each degree marked downward indicates a density equal to one per cent. of common salt. The hydrometer for liquids lighter than water is poised so that the zero point of the scale is at the bottom of the stem when it is floating in a solution of 1 oz. of common salt in 9 oz. of water, and the depth to which it sinks in distilled water shows 10°, the space between these two points being equally divided, and the same graduation continued to the top of the scale.* Fig. 222 is an illustration of a Baumé hydrometer having the two different scales. For liquids lighter than water the figures on the left hand side are read, and for liquids heavier than water those on the right hand side.

TABLE SHOWING THE RELATION BETWEEN SPECIFIC GRAVITIES AND DEGREES OF BAUME'S HYDROMETER FOR LIQUIDS HEAVIER THAN WATER.

S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.
1.000	0	1.116	15	1.264	30	1.454	45	1.714	60
1.007	1	1.125	16	1.275	31	1.470	46	1.736	61
1.014	2	1.134	17	1.286	32	1.485	47	1.758	62
1.022	3	1.143	18	1.298	33	1.501	48	1.779	63
1.029	4	1.152	19	1.309	34	1.526	49	1.801	64
1.036	5	1.161	20	1.321	35	1.532	30	1 823	65
1.044	6	1.171	21	1.334	36	1.549	51	1.847	66
1.052	7	1.180	22	1.346	37	1.566	52	1.872	67
1.060	8	1.190	23	1.359	38	1.583	53	1.897	68
1.067	9	1.199	24	1.372	39	1.601	54	1.921	69
1.075	10	1.210	25	1.384	40	1.618	55	1.946	70
1.083	11	1.221	26	1.398	41	1.637	56	1.974	71
1.091	12	1.231	27	1.412	42	1.656	57	2.002	72
1.100	13	1.242	28	1.426	43	1.676	58	2.031	73
1.108	14	1.252	29	1,440	44	1.695	59	2.059	74
								2.087	75

In the above scale 0 corresponds to pure water at 58° Fahr., and the numbers 1, 2, 3, etc., correspond to water containing 1, 2, 3, etc., per cent. by weight of common salt.

*NOTE.—These instruments were originally adjusted by Baumé to a temperature of 12.5° Centigrade, equal to 54.5 Fahrenheit. Now however, they are commonly adjusted in this country to a temperature of 58° or 60° Fahrenheit. Hence the discrepancies so often observed between degrees of Baumé and real specific gravity.

TABLE FOR LIQUIDS LIGHTER THAN WATER.

S.G.	B.	S.G.	B.	S.G.	B.	G.S.	B.
1.000	10	.918	23	.849	36	.789	49
.993	11	.913	24	.844	37	.785	50
.987	12	.907	25	.840	38	.781	51
.980	13	.901	26	.834	39	.777	52
.973	14	.896	27	.830	40	.772	53
.967	15	.890	28	.825	41	.769	54
.960	16	.885	29	.820	42	.764	55
.954	17	.880	30	.816	43	.760	56
.948	18	.874	31	.811	44	.756	57
.942	19	.870	32	.807	45	.753	58
.936	20	.864	33	.802	46	.749	59
.930	21	.859	34	.798	47	.745	60
.924	22	.854	35	.794	48		

As the whole weight of the hydrometer and the weights when adjusted in distilled water is to the *number* 1,000, so is the *whole weight when adjusted in any other fluid to the number expressing its specific gravity.*

Nicholson's Hydrometer or *Areometer* is constructed on a similar plan to Fahrenheit's. It has, however, in addition to the dish for the weights above, a small cup below for convenience in ascertaining the weight of a solid body in water. It is chiefly used for ascertaining the specific gravity of minerals (see fig. 63).

Fahrenheit's Hydrometer.—This instrument consists of a little hollow ball, having a counterpoise below, and a very slender stem above terminating in a small dish. The half length of the stem is distinguished by a fine line across it. The instrument is immersed in the liquid to this line by placing weights in the little dish above. Then, seeing that the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known, the last weight, added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, according to the laws of hydrostatics. The specific gravity will be found by the proportion.

Twaddle's Hydrometer.—With this instrument 0 is equal to 1,000, or the spec. grav. of distilled water, and each degree is equal to ·005, so that by multiplying this number by the number of degrees marked on the scale and adding 1 the real spec. grav. is obtained.

Alcoholmeters, Argentometers, etc., are all simple hydrometers graduated so as to adapt them to the testing of spirits, silver solutions, etc.

HYDROQUINONE (Formula $C_6H_6O_2$; molecular weight, 110; synonyms, *quinol, hydrokinone, hydrochinone, pyroquinol, pyrogentisic acid*).—A constant product of the action of reducing agents on quinone. The most convenient method of preparing it is by passing sulphur dioxide (sulphurous acid gas) through a warm saturated solution of quinone. It is also prepared commercially by oxidizing aniline sulphate with potassium dichromate. Hydroquinone is isomeric with pyrocatechin,* but is distinguished from it by the action of oxidizing agents, such as ferric chloride, which converts hydroquinone into fine green metallic prisms of green hydroquinone or quinhydrone, $C_6H_4O_2C_6H_4(OH)_2$, which may also be obtained by mixing aqueous solutions of quinone and hydroquinone.

Hydroquinone is dimorphous, crystallizing in monoclinic plates and from solutions in hexagonal prisms. It has a slightly sweet taste, and is soluble in water, ether, alcohol, and glycerine. An aqueous solution slowly turns brown on exposure to the air, losing its reducing power, and if it be alkaline it will brown more rapidly.

It has recently been discovered to be an excellent developing agent for dry plates, bromide paper, transparencies, etc., bringing out the detail to perfection. Further, it allows of a great latitude in the exposure, as it is slow in action, and consequently easily controlled.

Commercial hydroquinone is usually in the form of nearly white or pale yellowish needle-like crystals. These must be kept protected from light and damp, otherwise they will darken. The best method of preserving it is in solution with alcohol and glycerine, and used either with ammonia or the fixed alkalies, potash, and soda, as accelerators. The following are two such solutions:†

Hydroquinone	8 grains
Glycerine	1 drachm
Methylated spirit	7 drachms.

Keep in stoppered bottle, excluded from light.

Hydroquinone	8 grains
Citric acid	8 grains
Distilled water	8 drachms

* "Bloxham's Chemistry," page 651.

† E. J. Wall's "Dictionary of Photography," page 37.

The use, however, of a preservative such as potassium metabisulphite, or solution sulphite, is always an advantage, as it enables a large number of plates to be treated with the same developer without fear of producing stains or discoloration.

A good formula for a hydroquinone developer for dry plates is the following :—

Hydroquinone	1 grain
Sodium carbonate	2 grains
Sodium sulphite	2 grains
Potassium bromide	1 ounce

One of the chief features of this developer is that a restrainer is rarely necessary, as it does not possess the vigor of pyrogallic acid in attacking the very lightly exposed portions of the image. It does not, however, suit every manufacture of plates. With some it hardly seems to have any developing action, while with others it brings up a clear, sharp, and brilliant negative.

It is also a very suitable developer for bromide paper, or developing contact prints or enlargements. For this purpose the formula reads :—

SOLUTION 1.

Hydroquinone	350 grains
Sodium sulphite	2 ounces
Potassium bromide	45 grains
Water	45 ounces

SOLUTION 2.

Potash (ordinary granulated)	6 ounces
Sodium carbonate	2 ounces
Water	40 ounces

This gives a rich black color to the image.

Another formula is—

Bitartrate of potash	90 grains
Potassium sulphite	45 grains
Potassium carbonate	4 ounces
Water	16 ounces

Filter and add—

Hydroquinone	½ ounce

A developer for chloride plates for lantern or other transparencies can be made up as follows :—

Hydroquinone	2 grains
Sodium sulphite	10 grains
Ammonium carbonate	10 grains
Potassium bromide	1/10 grains
Water	1 ounce

A simple hydroquinone developer, made up in a solution that will keep for a great length of time is the following :—

Hydroquinone	10 grains
Sodium sulphite	20 grains
Lime water	2 ounces

For use, take 100 minims of the above solution and dilute it with one ounce of water. This developer is specially suitable for lantern slides or transparencies. For negatives double the strength would be required.

Hydroquinone also acts as an efficient intensifier, and is especially suitable for the production of very dense collodion negatives as used in photo-mechanical printing processes. The following formula was introduced by Captain Hübl, of Vienna :—

SOLUTION 1.

Hydroquinone	10 parts
Water	1,000 parts
Citric acid	6 parts

SOLUTION 2.

Silver nitrate	1 part
Water	30 parts

For use take three parts of solution 1, and mix with one part of solution 2. According to Professor Eder, this intensifier not only effects, with an unfixed wet collodion plate, a harmonious strengthening of the image, but it also continues the action of the developer that has preceded it, and brings out the details. If applied after fixing no injury to the clear shadows takes place.

HYDROXYSUCCINIC ACID.—See **Malic acid.**

HYDROXYLAMINE HYDROCHLORIDE (Formula, NH_3OHCl; molecular weight, 69.5; synonym, *oxyammonium chloride*).—Colorless tubular crystals, very soluble in water and alcohol.

The best method of preparing it is probably the following, given by Ruschig:—

Hydrogen sulphite in concentrated aqueous solution is added to an alkaline nitrate at a temperature not exceeding freezing if the soda salt be used, or 40 deg. of the potassium salt; or the same product is obtained by passing sulphurous anhydride to excess in a solution of the alkaline nitrate, containing also a carbonate or hydroxide. The resulting solutions being heated for a short time at 130 deg., or a longer period at 100 deg., are resolved into hydroxylamine and alkaline sulphates, easily separable by fractional crystallization. It was recommended in 1884 by Messrs. Egli and Spiller as a developer claiming a wide latitude in exposure and permanency of the solution, unaffected by the air. Their formula runs as follows:—

SOLUTION 1.

Hydroxylamine hydrochloride	32 grains
Citric acid	15 grains
Distilled water	1 ounce

SOLUTION 2.

Potassium carbonate	480 grains
Sodium carbonate	480 grains
Distilled water	1½ ounces.

DEVELOPER SUFFICIENT FOR HALF-PLATES.

Solution 1	30 minims
Solution 2	120 minims
Distilled water	1½ ounces

This developer will be found more suitable for chloride plates and bromide contact and enlarging papers.

The hydroxlamine is usually obtained by the reduction of nitric acid with tin and hydrochloric acid. Chapman Jones says* that a simple solution of this salt appears to be useless as a developer, and the addition of ammonia or sodium carbonate makes but little difference; with caustic potash or caustic soda, however, a solution can be prepared that will give as much detail as an ordinary pyrogallic developer.

In the production of the image the chemical changes that in all probability takes place are thus expressed:

$$_2NH_3OHCl + 6NaOH + 4AgBr = 4Ag + 4NaBr + 2NaCl + 7H_2O + N_2O$$

One of the principal drawbacks to this developer, besides its expensiveness, is its peculiar expanding action upon the gelatine film, causing frilling.

HYDROXYPHENOL GLYCIN.—See **Glycin.**

HYGROMETER.—An instrument for measuring the degree of moisture of the atmosphere. The principle of these hygrometers depends chiefly upon absorption or condensation. An instrument of this kind is often useful in the photographic laboratory to detect the amount of moisture in the atmosphere. A very simple one was constructed and used by the late W. B. Woodbury in his laboratory. It consisted simply of a piece of carbon tissue fixed in an upright support. The piece of carbon tissue absorbed the moisture of the air, the gelatine expanded, and the strip was made to move or curl downwards. On a piece of cardboard at the back a scale was drawn showing the amount of moisture present.

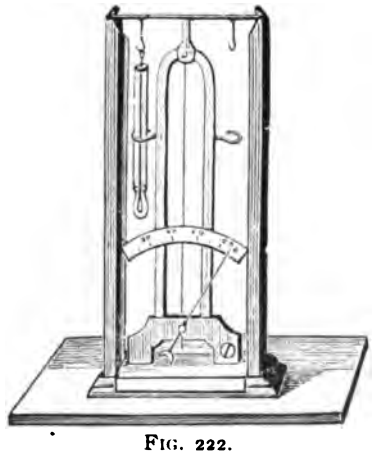


FIG. 222.

For more delicate purposes, however, the most efficient hygrometer is one recently invented by Dr C. Koppe.* Fig. 222 is an illustration of it. It consists of a frame, to which one end of a human hair, carefully freed from grease, is fixed, the other end is wound round one groove of a pulley wheel with two grooves. Round the second groove a filament of silk is wound in a reverse direction to that of the hair, and, at the lower end of the hanging silk or filament, a little weight is attached, so that the hair is kept constantly under tension. An index needle attached to the wheel in front of a scale of 90 deg., divided into 100 parts, shows the amount of any elongation or contraction of the hair. When the hair grows dry the needle turns to the left, and when it becomes damp the needle turns to the right. If the surrounding air be completely saturated, the needle points to 100 on the scale.

* "Science and Practice of Photography."—Iliffe & Son.

* Photographic News," 1890, page 547.

HYPO.—An abbreviation for sodium thiosulphite, commonly called hyposulphite of soda, largely used as a fixing agent in photography. (See **Sodium Hyposulphite.**)

HYPOCHLORITES.—The salts of hypochlorous acids, usually obtained in solution by neutralizing hypochlorous acid with bases. They are oxidizing agents, and for this reason have been recommended for eliminating the last traces of sodium hyposulphite from the fixed and washed prints. Like all other so-called "eliminators," however, they have a tendency to attack the picture itself.

HYPO-ELIMINATORS.—See **Eliminators.**

HYPOSULPHITE OF AMMONIUM.—See **Ammonium Hyposulphite.**

HYPOSULPHITE OF GOLD.—See **Gold Hyposulphite.**

HYPOSULPHITE OF SODA.—See **Sodium Hyposulphite.**

ICE —Water frozen to a solid mass; under ordinary circumstances, this occurs at 32 deg. Fahr. Ice has a specific gravity of 0·9184. When in the act of freezing, water expands very considerably, and will burst any vessel which contains it. It is for this reason that in winter, when the weather is very cold, the room containing the various photographic chemicals should always be kept warm. Ice is very useful in photographic operations, especially in the summer. Many freezing mixtures can be made to act as substitutes. These are all given under **Freezing Mixture** (*q.v.*).

ICELAND MOSS (*Letraria islandica*).—A species of lichen found in the Arctic regions, and in the high parts of the mountainous districts in Scotland. If boiled in water and allowed to cool, it forms a jelly. It resembles gelatine in many ways, and can be used in its stead. It is, however, inferior.

ICELAND SPAR.—A transparent variety of calc spar found in crystallized masses. It is noted for its peculiar property of exhibiting double refraction of light to a remarkable degree, and is used in experiments on polarized light.

ILLUMINATING LENS.—A large lens, which has for its purpose the concentration of the light from the sun or a lamp at the focus, is sometimes termed an illuminating lens. Condenser is, however, the more general term.

ILLUMINATION.—The illumination of a surface varies inversely as the square of its distance from the source of light. The same quantity of light which falls upon a certain area at a distance of one foot from the illuminant will become extended over four times that area if the distance be increased to two feet, nine times at a distance of three feet, 16 times at a distance of four feet, and so on. If, therefore, in contact printing or enlarging, an exposure of one second is required at a distance of one foot from the illuminator, four seconds will be required at two feet, and so on.

IMAGE.—An optical term, denoting the representation of objects formed by concourse of the pencils of rays proceeding from the various points of the object which it represents. In optics, a luminous body is considered to be an assemblage of luminous points, from each of which a pencil of light proceeds, without interfering with each other. When an image is formed in the focus of a lens, and can be received on a screen, as, for example, at the focus of a convex lens it is termed *real* or *positive*. When, however, it is not formed by the actual union of rays in a focus, but only apparently so, and cannot be received on a screen, it is termed a *virtual* image. The following useful remarks regarding this subject are from Sir T. Longmore's optical manual:—"An image is *erect* when the object and image lie on the same side of the center of the lens; is *inverted* when the object and image lie on the opposite side of the center. The retinal image of an object situated in front of the eye is an example of a *real* and *inverted* image. The diameters of an object and its image are directly as their distances from the center of the lens; as they separate from this point, the farther off either is, the greater its proportionate size. (**Conjugate Foci.**)

When an object is placed between a *convex* lens and its principal focus, an eye on the other side of the lens sees a *virtual* image of the object erect, magnified on the *same side* of the lens as, but at a greater distance from it than, the object.

When an object is placed in front of a *concave* lens, an eye on the other side of the lens sees an image of the object, which is virtually erect, and diminished on the same side of the lens as, and nearer to it than, the object. The image is diminished when the distance between the lens and the object is increased, but when the distance of the object is a large multiple of the focal length of the lens, further increase of its distance does not appreciably alter the distance of the image, or consequently its size.

The image formed by a lens on the screen of the camera is a *real* image, and its distinctness will depend upon the accuracy with which the rays of each pencil are brought to a focus. When an object is placed at a distance in front of the lens an image is formed on the ground glass screen of the camera smaller than the object itself. But if the object be brought nearer the lens the image will increase in size until it becomes equal to, and afterwards larger than, the original. The focus will, at the same time, recede to a greater distance from the lens. (See also **Optics, Vision, Light,** etc.)

IMAGE, LATENT.—See **Latent Image.**

IMAGE, REVERSAL OF.—See **Solarization.**

IMPERIAL MEASURE.—See **Weights and Measures.**

INCIDENCE, ANGLE OF.—The angle of incidence is the angle which a ray of light falling on a surface forms with the perpendicular to that surface, or to the tangent if curved. The angle formed by the perpendicular and the line of departure is termed the angle of reflection, and is always equal to the angle of incidence.

INCIDENCE, LINE OF.—The straight line taken by a ray of light moving to strike a plane at an acute or right angle.

INCORRODIBLE INK.—Under this heading Sutton, in his "Dictionary of Photography," gives the following instructions for making an incorrodible ink for writing the labels on bottles which contain strong acids or alkalies: Dissolve one part of asphaltum in two parts of oil of turpentine.

Another formula is—Boiled linseed oil, ground with lampblack and Prussian blue—of each quantity sufficient to impart a deep black color—then with oil of turpentine.

INDEX OF REFRACTION.—See **Refractive Index.**

INDIAN INK.—A black pigment manufactured in China, and should therefore be called Chinese Ink. It is composed of an exceedingly fine lampblack, produced by burning oil of sesame mixed with some vegetable gum, and afterwards dried in the sun until it turns into a cake. It is sold in sticks and cakes. Inferior kinds are manufactured in this country. It is largely employed in coloring.

INDIA RUBBER.—See **Caoutchouc.**

INDIA RUBBER CEMENT.—A cement for indiarubber may be prepared as follows:

Carbon bisulphide	5 ounces
Gutta percha	5 drachms
Indiarubber	10 drachms
Fish glue	20 drachms

INDIA RUBBER CLOTH.—A very useful material for many photographic purposes. It forms an excellent camera focusing-cloth, and can be used in case of a sudden shower, to protect the camera from the rain. It is also used to lay over carbon or gelatino-chloride prints when the squeegee is applied to attach them to the glass.

INDIA RUBBER SOLUTION—A solution made by dissolving india rubber in benzole, ether, naphtha, chloroform, or any other of its solvents. Used in photographic operations for various purposes. A solution of rubber is used occasionally for mounting prints, and is especially suitable for gelatino-chloride high-surfaced prints, as this mountant does not affect the gloss.. A little of the solution is sometimes run round the plate to prevent frilling. It is also employed as a substratum in the collodion and albumen processes.

INDIGO.—A vegetable coloring matter, obtained chiefly from the leaves of the various species of *Indigofera, Isatis tinctoria,* etc. Its luster is dark coppery red, semi-metallic when in mass, and deep blue when in powder. It is insoluble in water, cold alcohol, and ether, slightly soluble in boiling water, but very soluble in concentrated sulphuric acid.

INDOTINT.—A photo-mechanical process invented by Roche, of New York. In this a copper plate roughened by exposure to the sand-blast to cause the sensitive film to adhere firmly is used instead of the glass plate. The rest of the process is similar to the collotype.

INFINITE RAYS.—A term employed in optics to express rays of light proceeding from an object and entering the eye in parallel lines, or, more correcting speaking, in lines which are so

nearly parallel to each other that the amount of divergence is inappreciable, and the expression "infinite distance," or *infinity*, is applied to the distance from which the incident rays possessing, collectively, such a parallel direction might have originally started.

INK.—A liquid or pigment used for writing or printing.

Writing Ink.—Take 4 oz. of well-bruised Aleppo galls in 1 quart of clean soft water, and maccrate in a clean corked bottle for a fortnight or so, with frequent agitation. Next add 1½ oz. of gum arabic and ½ oz lump sugar dissolved in a wineglassful of water; mix well and add 1½ oz. of sulphate of iron (green copperas) crushed small. Shake the bottle well up for two or three days, and allow it some time to digest. One quart of good writing fluid will be the result. The writing will be pale at first, afterwards turning a deep black.

Copying Ink.—This is manufactnred by adding a little saccharine matter to an ordinary black ink. The following proportions are employed :—Sugar candy or lump sugar, 1 oz. or treacle or moist sugar, 1½ oz., dissolved in 1½ pints rich black ink.

Colored Inks can be made from a strong decoction of the ingredients used in dyeing processes, mixed with a small quantity of alum and gum arabic.

Indelible Ink.—Lampblack ground in a lye of caustic soda, combined with a mixture of gelatine and caustic soda, is said to be indelible. Many other inks have been recommended that will resist the action of chemicals. A quarter of an ounce of lampblack (previously heated to dull redness in a covered vessel), triturated with one pint of good black ink, added gradually, will form an ink that will resist chlorine and weak acid and alkaline lyes.

Marking Ink.—Made by dissolving ¼ ounce of silver nitrate in ¾ ounce of water, and adding as much of the strongest liquid ammonia as will dissolve the precipitate formed when it is first added. Next add 1½ drachms of mucilage, and a small quantity of finely-powdered indigo or syrup of buckthorn to color. The writing will turn black if held to the fire, or if passed over a hot iron.

Printing Ink.—Inks used for printing consist chiefly of well-boiled drying oils mixed with lampblack or other pigments. Soaps and resins are also frequently added to give the required consistency.

Lithographic Ink.—Thirty parts each of dry tallow, soap, mastic (in tears), and common soda (in fine powder), 150 parts of shellac, mixed with 12 parts of lampblack.

Autographic Ink.—Ten ounces each of white soap and white wax, 3 ounces of mutton suet, and 5 ounces each of shellac and mastic. Mix with 3½ ounces of lampblack.

Eikonogen as Ink.—Eikonogen has proved such a successful developing agent that it is usually found in every photographic laboratory. It is not generally known, however, that a very fine writing fluid can also be made with it. To accomplish this, boil a quantity of it in a flask so as to make a saturated solution. When quite cold it is decanted from the crystals, and without requiring any further addition to be made to it, can be used as a writing fluid. It will be found to flow easily from the pen, and has no objectionable tendency to thicken or corrode the steel pen. The solution itself is of a reddish brown color, but when applied to paper, however, it becomes of a pure rich black.

Ink for Writing on Photographs.—Make up a solution of

Iodide of potassium	10 parts
Water	30 parts
Iodine	1 part
Gum	1 part

An ordinary pen is used, and the writing with this fluid is made on the dark portions of the photograph. The action of the solution is to bleach by converting the silver into silver iodide, and thus it is possible to obtain white letters, which show well on the black or dark ground.

INK PHOTO.—A term applied to the products of several photo-mechanical printing processes.

INK PICTURES.—Ink pictures can be made from photographs by a very simple means, and one that is often employed by artists. A print is first made upon plain salted paper, the image being brought out until the most important details appear. These are traced over with a pen and ink, using the photograph as a guide. When dry the print is bleached in a solution of perchloride of mercury. This has the effect of causing the photographic image to entirely disappear, leaving the ink sketch standing alone.

INK PROCESS.—A method of obtaining positive prints in ordinary writing ink. A good quality of paper is first immersed in a nearly saturated solution of potassium dichromate, and dried in the dark. When dry, the paper will have a bright yellow color. It is then placed under the negative in a printing-frame and printed until all the details appear. The picture will appear as a brownish image on a yellow ground. The time required in printing is somewhat less than for albumenized paper.

The prints are first washed in water to eliminate the undecomposed chromium salts. The washing operation must take place in the dark, and requires about two or three hours with running water. The print is now fixed, and should appear as a brown image upon a white ground.

The next process is to color the image black or purple. This is accomplished by causing writing ink to adhere to the dark portions of the picture, acting as a mordant. To do this the print is immersed in a weak aqueous solution of ferrous sulphate (five grains to the ounce of water), and allowed to remain therein for a few minutes, when it is removed, immersed in a weak solution of hypochloric acid for 15 minutes, and thoroughly washed in several changes of water. It is then immersed in a strong solution of tannin (20 grains to the ounce), when the image will instantly turn black, this change being due to the formation of tannate of iron or writing ink. The light should remain unchanged if the print has been properly exposed.

INSENSITIVENESS.—The insensitiveness of substances which should be sensitive is usually caused by careless manipulation or faulty chemicals, the action of light having little or no effect upon them. In many cases time will also render sensitive material insensitive.

INSOLATION.—Exposure to the heat of the sun.

INSTANTANEOUS.—A word much used in photography in connection with exposure, shutter, dry plates, lenses, etc. The term "instantaneous exposure" is usually applied when the duration of the exposure is a fractional part of a second. An instantaneous shutter is one that will allow of such exposures being made, and instantaneous dry plates are those coated with a very highly-sensitive emulsion that will become sufficiently impressed by the rapid exposure of the image upon it. An instantaneous lens is one that admits a large amount of actinic light. For instantaneous work the rapid rectilinear is the most suitable, because it works with a large aperture, which is the essential point in a rapid lens. So-called instantaneous portrait lenses are now manufactured, by means of which portraits of restless children can be taken in the studio in a fraction of a second. This lens, of course, gives sharp definition with a wide aperture. The purity of the lens will also affect its rapidity; with some the glass absorbs the chemically-active rays, and makes it useless for instantaneous photography.

Taken with a Prosch Mf'g Co's "Athlete Shutter." Copyright, 1896. By J. BURTON.

FIG. 223.—THE START, INSTANTANEOUS PHOTOGRAPHIC. BY JAMES BURTON.

intensifying, by which the deposit is not only increased, but a change in color also takes place. It will be as well to state that it is useless endeavoring to improve the printing qualities of a much over-exposed or fogged negative by intensification, because nothing will be gained, and the lack of contrast will become more apparent.

INSTANTANEOUS PHOTOGRAPHY.—In the very earliest days of photography this term was applied to what would now be considered very slow work indeed. We now usually apply this term when the exposure does not exceed one second. In some cases this only amounts to the one-thousandth part of a second. This exceedingly brief exposure is usually given to the plate by means of a suitably constructed shutter.

The immense strides that have recently been made in instantaneous photography, owing chiefly to the advent of the dry-plate process, have caused photography to become useful to almost every branch of science.

To Marcy, Muybridge and Anschütz we are greatly indebted for the strides made in instantaneous photography. These gentlemen have succeeded in photographing moving objects hitherto considered impossible to be photographed. Galloping horses, swift-flying birds, and even bullets and cannon-balls projected from guns have been successfully photographed, showing even the little head of air driven along in front of the bullet.

Both Muybridge and Anschütz have also succeeded in making series of twenty-four or more photographs of a horse during the time it makes a single leap, and thus illustrate its every movement. The value of these and other possibilities with the camera for artists cannot be overestimated. Its aid to meteorologists in photographing the lightning, to astronomers in stellar, lunar, and solar photography, and to all other sciences would require a work as large as this to describe.

For the making of instantaneous pictures a large number of suitable cameras have been devised. In most of these the lens is a very rapid one, and in some cases so arranged that all objects beyond a certain distance are in focus. With an instantaneous camera a secondary image is necessary, so that the right second can be judged for making the exposure. This is usually produced by a finder. In making instantaneous exposures the following tables may be useful:

	Approximate distance per second.
A man walking 3 miles per hour moves	4½ feet per second
A man walking 4 miles per hour moves	6 " "
A vessel traveling at 9 knots per hour moves	15 " "
A vessel traveling at 12 knots per hour moves	19 " "
A vessel traveling at 17 knots per hour moves	28 " "
A torpedo boat traveling at 20 knots per hour moves	35 " "
A trotting horse	36 " "
A galloping horse (1,000 yards yer minute)	50 " "
An express train traveling at 38 miles an hour	59 " "
Flight of a pigeon on falcon	61 " "
Waves during a storm	65 " "
Express train (60 miles an hour)	88 " "
Flight of the swiftest bird	294 " "
A cannon ball	1,625 " "

An object moving—

1 mile per hour moves	1⅓ feet per second.
2 " "	3 " "
5 " "	7 " "
6 " "	9 " "
7 " "	10½ " "
8 " "	12 " "
9 " "	13 " "
10 " "	14½ " "
11 " "	15 " "
12 " "	17½ " "
15 " "	22 " "
20 " "	29 " "
25 " "	37 " "
30 " "	44 " "
35 " "	51 " "
40 " "	59 " "
45 " "	66 " "
50 " "	73 " "
55 " "	80 " "
60 " "	88 " "
75 " "	110 " "
100 " "	147 " "
125 " "	183 " "
150 " "	220 " "
200 " "	257 " "

With these tables it will be very easy to find the distance that the image of the object will move on the ground glass screen of the camera. To do this, multiply the focus of the lens in inches by the distance moved by the object in the second, and divide the result by the distance of the object in inches.

Example, find the movement of the image of an object moving 50 miles per hour at a distance of 100 yards with a lens of 9-inch focus.

$$9 \times 876 = 7{,}884 \div 3{,}600 = 2\tfrac{1}{8} \text{ inches per second.}$$

We mast also find out the speed of the shutter required to take the object in motion, so that it will appear as sharply defined as possible under the circnmstances. To do this the circle of confusion must not exceed $\frac{1}{100}$th of an inch in diameter. We therefore divide the distance of the object by the focus of lens multiplied by 100, and then divide the rapidity of the object in inches per second by the result obtained. This will give the longest exposure permissible in the fraction of a second. For example, we require to know the speed of a shutter required to photograph an express train traveling at the rate of 50 miles per hour at a distance of 50 yards with an $8\frac{1}{2}$-inch focus lens.

The train moves 876 inches per second.

$$1{,}800 \text{ distance in inches} \div (8\tfrac{1}{2} \times 100) = 1{,}800 \div 850 = \tfrac{36}{17}.$$

$$876 \text{ speed of object per sec.} \div \tfrac{36}{17} = \frac{876 \times 17}{36} = 413 = \tfrac{1}{413} \text{ sec.}$$

FIG. 224.—INSTANTANEOUS PHOTOGRAPH.

Given the rapidity of the shutter, and the speed of the moving object, we require to find the distance from the object the camera should be placed to give a circle of confusion less than $\frac{1}{100}$th of an inch. Multiply 100 times the focus of the lens by the space through which the object would pass during the exposure, and the result obtained will be the nearest possible distance between the object and the camera. For example, we have a shutter working at one-fiftieth of a second, and the object to be photographed moves at the rate of 50 miles per hour. How near can a camera fitted with with a lens of $8\frac{1}{2}$-inch focus be placed to the moving object?

Object moving 50 miles per hour moves per second 876 inches, and in the one-fiftieth part of a second it moves 17.52 inches, so that—

$$8\tfrac{1}{2} \times 17.52 = 8.5 \times 100 \times 17.52 = 14{,}892 \text{ inches} \quad 413 \text{ yards}$$

Instantaneous photography can only be successfully performed in very bright actinic light, and should never be attempted on dull days, as under-exposure will be the inevitable result. In developing it is necessary to employ a strong developer to bring up the detail. Some operators make use of an accelerator for this purpose, but it is not to be recommended; the simplest is a few drops of hyposulphite of solution added to about 10 ounces of water. In this the plate is bathed for a few seconds previous to development.

The following is a table by H. E. Tolman showing displacement on ground glass of objects in motion:

FIG. 225.—INSTANTANEOUS PHOTOGRAPH.

Miles per Hour.	Feet per Second.	Distance on Ground Glass, in Inches with Object 30 feet away.	Same with Object 60 feet away.	Same with Object 120 feet away.
1	1½	.29	.15	.073
2	3	.59	.29	.147
3	4½	.88	.44	.220
4	6	1.17	.59	.293
5	7½	1.47	.73	.367
6	9	1.76	.88	.440
7	10½	2.05	1.03	.513
8	12	2.35	1.17	.587
9	13	2.64	1.32	.660
10	14½	2.93	1.47	.733
11	16	3.23	1.61	.807
12	17½	3.52	1.76	.880
13	19	3.81	1.91	.953
14	20½	4.11	2.05	1.027
15	22	4.40	2.20	1.100
20	29	5.87	2.93	1.467
25	37	7.33	3.67	1.833
30	44	8.80	4.40	2.200
35	51	10.27	5.13	2.567
40	59	11.73	5.97	2.933
45	66	13.20	6.60	3.300
50	73	14.67	7.33	3.667
55	80	16.13	8.06	4.033
60	88	17.60	8.80	4.400
75	110	22.00	11.00	5.500
100	147	29.33	14.67	7.333
125	183	36.67	18.33	9.167
150	220	44.00	22.00	11.000

INTENSIFICATION.—Any method of increasing the opacity of a negative. It frequently happens that either from under-exposure, insufficient development, or other cause, the negative does not possess sufficient density to yield satisfactory prints. It will then be necessary to "intensify" it, or increase the opacity by "intensification" with an "intensifier."

There are two chief methods of intensification very distinct from each other in the actions of the chemicals used. The first is a method of increasing the density by thickening the deposit of metallic silver, and the second is by substituting another metal for the silver, having a more opaque color, causing the negative to become less transparent. There are also other methods of

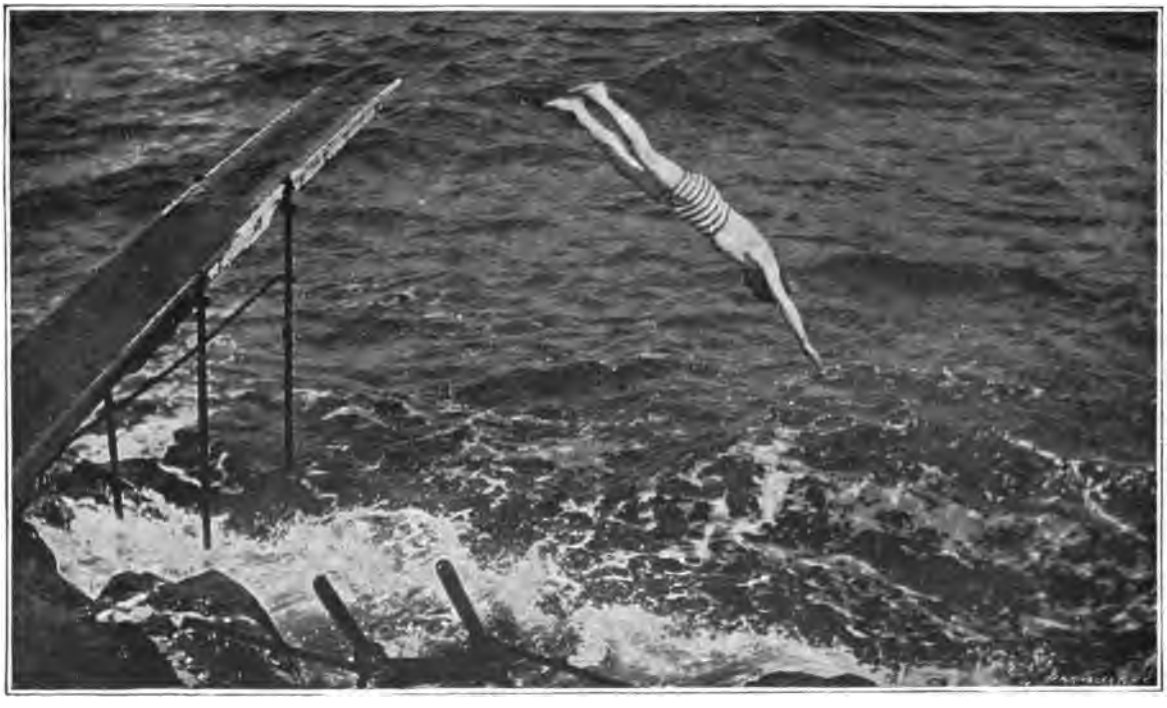


FIG. 226.—THE DIVER, INSTANTANEOUS PHOTOGRAPH. BY LOUIS MELDON.

A method of intensifying that has found considerable favor with practical workers is the following: The plate is first of all thoroughly freed from the hypo, and immersed in a ten per cent. solution of perchloride of mercury until the image becomes bleached and appears quite white on both sides of the film. It is then thoroughly washed. A solution of silver nitrate (100 grains in 10 ounces of water) is then taken, and sufficient potassium cyanide in solution added, to nearly dissolve the precipitate first formed on making the addition. In this solution the bleached negative is laid, when it will at once commence to darken. When the required density is obtained it is removed. It will be necessary to bear in mind that the negative, while wet, will appear slightly denser than when dry. Also the plate should not be allowed to remain too long in the silver cyanide solution or reduction will take place. The chemical actions that take place with this method are briefly these. The mercuric chloride becomes reduced when it comes into contact with the silver image, and forms calomel mercurous chloride and silver chloride, thus—

$$2\,HgCl_2 + 2Ag = Hg_2Cl_2 + 2AgCl.$$

The potassium cyanide and silver can be taken as a solution of silver cyanide, reduced by the mercurious chloride to a dense black deposit of metallic silver.

There are a number of other methods of intensifying the image, by first bleaching it with mercury and afterwards darkening it with other chemical agents.

The negative is laid in the bleaching solution composed of—

Mercury perchloride	100 grains
Potassium bromide	100 grains
Distilled water	10 ounces

until the silver image is whitened. To do this properly it is absolutely necessary that the negative be free from hyposulphite of silver, otherwise stains will be the inevitable result.*

When the negative is perfectly white when viewed both from the front and back of the film, the plate is removed and thoroughly washed. We have now to change the color of the image to a more opaque one. This can be done in several ways. If the plate be immersed in a weak solution of ammonia, the chloride of silver will become dissolved away, and the mercurous chloride is changed into mercurous ammonium chloride (a dark colored substance) and ammonium chloride, thus

$$Hg_2Cl_2 + 2NH_3 = NH_2Hg_2Cl + NH_4Cl.$$

If ammonium sulphide be used instead of ammonia the mercurous chloride will be split up into mercuric sulphide and finely divided mercury, and the silver chloride will become converted into a form of silver sulphide. By this means we get a very dense negative, the process being more suitable for intensifying photographs of line drawings for photo-mechanical printing.

If the plate, after being bleached and washed, be treated to a solution of sodium sulphite, the action that will take place will be represented thus

$$2Hg_2Cl_2 + 4AgCl + 8Na_2SO_3 = Ag_2 + Hg + NaCl + 3Hg(NaSO_3) \times 8\tfrac{1}{2}\ 2AgNaSO_3$$

A darkening action, the blackened image consisting of silver mercury, will commence at once, and when sufficient density is obtained, the plate is removed and thoroughly washed. This is probably the most convenient and easiest method of intensifying, as the washing of the plate after treating with the mercury need not be prolonged. The sodium sulphite solution should be of about ten per cent. strength, and slightly acidulated with a little citric acid.

Another method of darkening the bleached image is with ferrous oxalate. With this the mercurous chloride is reduced to metal, as with sodium sulphite, but the silver chloride also becomes reduced, thus

$$Hg_2Cl_2 + 2AgCl + 4FeC_2O_4 + 2K_2C_2O_4 = Ag_2 + Hg_2 + 2Fe_2(C_2O_4)_3 + 4KCl$$

By this method greater opacity is obtained than with the previous one. To prepare the ferrous oxalate solution pour one ounce of a saturated solution of ferrous sulphate into a vessel containing five or six ounces of a saturated solution of potassium oxalate, acidified with a little oxalic acid. Next add three or four ounces of water, and the solution is complete.

Instead of ferrous oxalate, an old hydroquinone developer can be used with very successful results.

The following method of intensifying has also been recommended, one of its advantages over other methods being that it is not necessary to be so particular with regard to the perfect elimination of the hyposulphite:—

Bichloride of mercury	60 grains
Water	8 ounces

To this is added a sufficient quantity of potassium iodide to nearly dissolve the red precipitate first formed. About 150 grains will be required. Next add 120 grains of sodium hyposulphite in crystals.

* MM. Torres Freres, of Mexico, state that by previously immersing the negative in a solution of common salt (1 in 100) for about half a minute; it is not necessary to be so particular regarding the absolute freedom from hyposulphite, as when so treated the yellow stains usually produced are avoided.

In this solution the plate is immersed until sufficient density is obtained. It is then placed for from ten to fifteen seconds in a weak fixing bath. Well wash and dry. The resulting image will consist of a double iodide of silver and mercury of a reddish brown color, with good printing qualities.

The following intensifier was recommended by Farmer :—

SOLUTION 1.

Silver nitrate	480 grains
Distilled water	12 ounces

SOLUTION 2.

Potassium bromide	360 grains
Distilled water	2 ounces

No 2 is added to No. 1, and the precipitate formed is collected thoroughly washed, and added to

Sodium hyposulphite	960 grains
Distilled water	6 ounces

The mixture is thoroughly well stirred, and then allowed to stand a few hours, when it should be filtered, and distilled water added to it to make up to 16 ounces.

To intensify, the plate is immersed in this solution for about five minutes. It is then drained and a ferrous oxalate developer applied. It is then washed and dried. Instead of the ferrous oxalate developer the following may be used—

Pyrogallol	4 grains
Distilled water	2 ounces
Silver solution	60 minims

with about 30 minims of a 10 per cent. solution of liquid ammonia .880 added immediately before using.

Uranium Intensifier.—Eder recommends the following method of intensifying with uranium. A solution is made up after the following formula :—

Uranium nitrate	15 grains
Potassium ferricyanide	15 grains
Water	4 ounces

In this the plate is immersed when the details in the shadows are first attacked, then the half-tones, and finally the high lights.

Another method is to first soak the plate in a solution of uranium nitrate (60 grains in 10 ounces of water), and then immerse it in a solution of potassium ferricyanide. The ferricyanide becomes converted into ferrocyanide, and the resulting image is formed of a compound of ferrocyanide of silver and uranium. With this process of intensification it will be necessary to entirely eliminate the hypo, otherwise a reduction of the uranic salt will take place, producing a chocolate-colored stain. This stain can be removed by immersing in a solution of soda or ammonia, but the density which has been given to the negative will disappear.

Intensification can be effected in many ways by substituting some other metal for the silver forming the image. For example, if the plate be heated with platinic chloride, or gold chloride solution, the image would be formed in platinum or in gold, thus

$$4Ag + PtCl = Pt + 4AgCl$$
$$3Ag + AuCl_4 = Au + 3AgCl$$

In the latter, however, the image would be reduced in density, as one atom of gold takes the place of three of silver.

Lead Intensifier.—Eder and Toth's ferrocyanide of lead intensifier is based upon the following chemical changes:

$$2K_6Fe_2Cy_{12} + 4Ag + 6Pb_2(NO_3)_2 = Ag_4FeCy_6 + 3Pb_2FeCy_6 + 12KNO_3$$

or, in simple terms, potassium ferridcyanide, silver, and lead nitrate form silver ferrocyanide, lead ferrocyanide, and potassium nitrate. This intensifier is but little used on account of its extreme liability to cause fog.

Potassium Permanganate Intensification.—This method of intensifying is an extremely old one, and was used in the wet collodion process. The theory is in all probability the following:

$$K_2Mn_2O_8 + 4Ag_2 = 4Ag_2O + K_2O + Mn_2O_3$$

or the silver of the image is attacked by the permanganate, and forms silver oxide, potassium oxide, and manganic oxide. The manganic oxide, being an insoluble compound, is precipitated on the silver, which, however, has been converted into oxide. This is more transparent than metallic silver, and in consequence requires to be reduced to silver by the application of a ferrous oxalate developer. The process is as follows: One drachm of a ten per cent. solution of potassium permanganate is diluted with two ounces of water, and the plate immersed in this solution for about fifteen minutes. Four drachms of a saturated solution of potassium oxalate and one

drachm of a saturated solution of ferrous sulphate are then mixed and added. Instantly intensification proceeds rapidly. When the required density is obtained the plate is thoroughly washed.

We have now considered the various means by which the opacity of the negative can be increased, and the theories of the different chemical actions that take place. To make this article, however, of more practical value it would be well to consider which is the best method, as the reader is very liable to become confused with so many. It is possible to formulate a system of intensification by which any degree of density can be obtained. With nearly all these intensifiers the negative must be thoroughly freed from the fixing soda. If a varnish negative is required to be intensified it will be necessary to first remove the varnish by soaking the plate in methylated spirit, and then gently rubbing it with a tuft of cotton-wool. If the negative has been allowed to become dry it will be advisable before applying the intensifier to soak the plate in a dish of distilled water.

We have, then, to consider the amount of additional density we require. By treating the plate with mercuric chloride, and afterwards with sodium sulphite, we obtain but a slight addition to the density. In many cases, therefore, when but little increase of opacity is required, this method of intensification is the one most to be recommended.

To obtain a full degree of density the method of treating the plate with mercuric chloride, and afterwards thoroughly washing and applying a ferrous oxalate solution, should be followed. By repeating the application of mercuric chloride and ferrous oxalate we obtain a still fuller degree of density. This experiment can be made any number of times, when a satisfactory amount of opacity is obtained.

When a very great degree of intensity is required, the mercury and ammonia, uranium and lead intensifiers can be used.

Collodion negatives are usually intensified with—

Pyrogallic acid	2 grains
Citric acid	2 to 4 grains
Water	1 ounce

or

Ferrous sulphate	5 grains
Citric acid	10 grains
Water	1 ounce

A few drops of a two per cent solution of silver nitrate is added, and the mixture flooded over the plate either before or after fixing.

Another method is with metol.

A

Metol	15 grammes
Citric acid	10 grammes
Distilled water	1 litre

B

Nitrate of silver	10 grammes
Distilled water	100 c.c.

This is employed in the same manner.

INTENSIFIERS.—Those agents which are employed to increase the opacity of the developed image to the chemically active rays, either by increasing the thickness of the deposit of metallic silver or by changing its color to one less transparent. (See **Intensification.**)

INTERFERENCE.—See **Optics.**

INTERIORS.—In photographing interiors, especially darkly lighted ones, the operator is confronted by several difficulties. First, the want of actinism in the light itself, and further, the excessive contrasts, the dark portions requiring such a long exposure that the high-lights become solarized, and the effect of halation is also produced. For churches or similar dark interiors, a dull day, or when the clouds obscure the sun, is a preferable time to make the exposure. In photographing private rooms, etc., blinds, can be hung over the windows to subdue the light. To avoid halation it is a usual practice to back the plate with some black substance. (See **Backing.**) Thickly-coated plates should also be used.

With regard to the lens to be employed, the rectilinear doublet is the one usually preferred although in confined situations a wide-angle lens will be necessary. It is usually necessary to have the picture as sharp as possible, therefore a very small stop will be used. To avoid distortion the swing-back must be perfectly vertical. No rule can be given for the exposure. It varies from ten minutes to three or four hours with an f/32 stop. A good plan to adopt is to expose for the shadows and let the high-lights take care of themselves. To make a *picture* it will be necessary to study the lighting effect, and hit upon the right time, as the interiors of buildings often present totally different and opposite appearances under different conditions of lighting. In developing interior negatives it will be necessary to force the detail out as much as possible.

INVISIBLE IMAGE.—See **Latent Image.**

INVISIBLE RAYS.—Those rays beyond the extreme violet and the extreme red of the spectrum. The former, although invisible, will darken sensitized paper. They are the most refrangible, and can be rendered visible by being passed into a solution of sulphate of quinine. Their undulations are the shortest. The invisible rays beyond the red end of the spectrum are for a certain distance calorific. They are the least refrangible, and have the longest undulations.

IODHYDRIC ACID.—See **Hydriodic Acid.**

IODIC ACID. (Formula HIO_3).—Prepared by boiling iodine with nitric acid. Crystallised iodic and forms white hexagonal tables, having the composition HIO_3Ag. This acid is more stable than chloric and bromic acids, its solution redden litmus paper, and afterwards bleaches it by oxidation.

IODIDES.—Combinations of iodine with a metal or with acid organic radicals. The metallic iodides are the ones principally used photography.

IODIDE OF AMMONIUM.—See **Ammonium Iodide.**

IODIDE OF BARIUM.—See **Barium Iodide.**

IODIDE OF CADMIUM.—See **Cadmium Iodide.**

IODIDE OF CALCIUM.—See **Calcium Iodide.**

IODIDE OF LITHIUM.—See **Lithium Iodide.**

IODIDE OF POTASSIUM.—See **Potassium Iodide.**

IODIDE OF SILVER.—See **Silver Iodide.**

IODIDE OF ZINC.—See **Zinc Iodide.**

IODINE (*Symbol, I.*)—An element occurring in thin dark colored laminæ, having a characteristic smell and a metallic luster. Iodine solutions are used in testing. It is sparingly soluble in water and more readily in alcohol.

IODISER.—Iodides of metals and alkalies are added to the collodion, and termed iodisers; when bromides are added they are termed bromisers. The iodides and bromides of zinc, potassium, ammonium, and cadmium are used, but chiefly the two last. The following table may be useful in showing the amounts of iodine in the iodides of the metals.

In 10 grains of potassium iodide there are	7·6455 grains of iodine
In 10 grains of cadmium iodide there are	6·9398 grains of iodine
In 10 grains of ammonium iodide there are	8·7586 grains of iodine
In 10 grains of magnesium iodide there are	9·1366 grains of iodine
In 10 grains of zinc iodide there are	7·9608 grains of iodine

IRIDESCENCE.—A term usually applied to the phenomena of interference colors as seen in thin films in a soap bubble, mother of pearl, etc. Iridescent colors sometimes make their appearance on the negative, also in a lens. Their appearance in the latter is due to a defect in the cementing together of the combinations. The lenses should be separated and re-cemented with Canada balsam.

IRIDIUM.—A very rare metallic element usually found with platinum. The compounds of iridium and chlorine assume many colors, hence the name.

IRIDIUM CHLORIDES.—These are the *dichloride* ($IrCl_2$) and *tetrachloride* ($IrCl_4$). They resemble the corresponding platinum chlorides in forming double salts with the alkaline chlorides. There is also a trichloride ($IrCl_3$), the solution of which has a green color and gives a yellow precipitate with mercurous nitrate and a blue precipitate soon becoming white, with silver nitrite.

IRIDIUM TONING.—Iridium in the form of a double salt of chloride and potassium has been recommended for toning purposes. A formula for this purpose will be found under *toning baths.*

IRIS DIAPHRAGM.—See **Diaphragm.**

IRON (Symbol, Fe; atomic weight, 56).—A well known metallic element. It occurs abundantly in nature as magnetic iron ore, or ferrous ferrate (Fe_3O_4); ferric oxide as specular iron ore, or red hematite; but it more often occurs as different varieties of ferrous carbonate, $FeCO_3$. Iron is a soft, tenacious, tough, malleable, ductile, silver white metal with a texture resembling vegetable fibre. Pure iron has a specific gravity of 7.8. It is not affected by dry air, but moist air containing carbonic acid quickly rusts it, forming a hydrate of the sesquioxide.

Iron is soluble in dilute hydrochloric acid and in sulphuric acid, forming ferrous sulphate.

It is used in photography for making ferrotype plates, which are merely thin sheets of the best Russian iron coated over with a thick black or chocolate color varnish. In this case the iron only acts as a support, no chemical action taking place whatever. Iron wire will prevent solutions of ferrous salts from oxidizing in the air.

IRON, AMMONIO-CITRATE OF.—Prepared by dissolving ferric oxide in citric acid and adding liq. ammonia .880 until the solution becomes neutral. It is sold in small transparent scales of a dirty reddish brown color, and having a peculiar odor. One part is soluble in 0.5 parts of water, but nearly insoluble in alcohol. Paper prepared with it bleaches in the light, but darkens again in the dark. It is used in the ferro prussiate process.

IRON, AMMONIA-SULPHATE OF (Formula, $Fe_2(NH_4)_2(C_2O_4)_4$. Prepared by dissolving ferric hydrate in oxalic acid, and adding ammonium oxalate. The green crystals should be kept in the dark, otherwise they will be partly reduced to the ferrous state. Solubility 90 in 100 parts of cold water, and 126 part 100 hot.

IRON, AMMONIO-SULPHATE OF (Formula, $Fe(NH_4)_2SO_4 6H_2O = 328$).—A double salt of iron and ammonium prepared by dissolving 139 parts of proto-sulphate of iron and 75 parts of ammonium sulphate together in a minimum of water, and afterwards placed in a basin to remain till the double salt crystallizes. It is soluble in five times its weight of water. It has been recommended as a substitute for ferrous sulphate on account of its greater stability. There is, however, but little advantage to be gained, and its action is much feebler. It has also been used for developing web-plates.

IRON CHLORIDES.—See **Ferrous Chloride** and **Ferric Chloride.**

IRON IODIDE (Formula, FeI_2; molecular weight, 310).—Formed by digesting iron filings or wire in water with pulverized iodine with an excess of metal. A greenish solution is formed, and on evaporation crystals may be obtained soluble in alcohol.

Iodide of iron is rarely, if ever, used as an iodizer in collodion, as proto-nitrate of iron will be formed in the silver bath and in the film. This acts as a developer, and rapidly blackens the bath. It also develops the image, so long as the plates are kept moist.

IRON OXALATE.—See **Ferrous Oxalate.**

IRON PERCHLORIDE.—See **Ferric Chloride.**

IRON PROTOACETATE (Formula, $FeO,C_4H_3O^3$).—Made by mixing two solutions containing equal equivalents of ferrous sulphate and lead acetate, and filtering out the sulphate of lead precipitate. This substance was sometimes used as the developer in the collodion process.

IRON SESQUIOXALATE.—See **Ferric Oxalate.**

IRON SULPHATES.—See **Ferrous Sulphate** and **Ferric Sulphate.**

IRRADIATION.—The act of irradiating or emitting beams of light. This term is also applied to the phenomenon more commonly known as halation (*q.v.*).

ISINGLASS.—The purest variety of gelatine, obtained from the swimming bladders of various species of fish, but principally of the sturgeon. The best kind of isinglass, known as "leaf," comes from Astrakan, other inferior varieties being imported from Brazil and Hudson Bay. It is prepared by first steeping the bladders in water, and then treating with various substances to remove grease and other foreign matter. It is then carefully washed and dried.

Isinglass is used in many cases instead of ordinary gelatine; some collotype printers prefer it. It is also used instead of gelatine in the printing of lantern slides by the Woodbury process. It is, however, considerably more expensive than ordinary gelatine, and therefore cannot be recommended in place of that substance except in cases where great advantage or superiority is derived from its use.

ISOCHROMATIC.—See **Orthochromatic.**

ISOCHROMATIC PROCESS.—See **Orthochromatic Process.**

ISOMERIDES.—See **Isomerism.**

ISOMERISM.—A term applied in chemistry to those bodies which are composed of those of the same elements in the same proportions, but differ either in their physical characteristics or chemical properties. Such bodies are said to be isomeric, metameric, or polymeric, also termed isomerides, metamerides, and polymerides.

Isomeric Bodies are those which show similar decompositions and changes when heated, or if treated with reagents, but differ in physical properties.

Metameric Bodies are those which exhibit dissimilar transformations when heated or when acted upon by reagents.

Polymeric Bodies are those which contain the same elements in the same proportion, but have different molecular weights.

ISOMORPHISM.—A term applied in chemistry to bodies which have the same crystaline form, but may be analogous or different in chemical constitution. Isomorphous bodies are generally arranged according to the crystallograph system. Bodies which crystalize in two different forms are termed *dimorphous.*

IVORINE.—Imitation ivory, a compound of caoutchouc, sulphur, and some white ingredients, such as gypsum, sulphate of baryta, oxide of zinc or pipeclay.

A good formula for making artificial ivory is as follows:

White shellac	10 ounces
Acetate of lead	4½ ounces
Ivory dust	8 ounces
Camphor	5 ounces

These ingredients are reduced to a powder, heated and mixed, then pressed in heated moulds, of made into sheets.

Pinson's process of manufacturing ivory is one much used on the Continent. Sheets of gelatine are immersed in alumina, dissolved in acetic acid. The two combine, and when the geletine has absorbed sufficient of the alumina, the sheets are hung up to dry, and when dry, are polished.

IVORY.—Specifically, the material constituting the tusk of an elephant, but the term also includes the tusks and teeth of the hippopotamus, walrus, norwhal, wild boar, and other animals.

The African ivory is preferred to any other.

Ivory can be make flexible by steeping in a solution of pure phosphoric acid, specific gravity 1·130, and leaving it in this solution until it loses their opacity. It is then washed and partially dried. It will become hard again, however, when perfectly dry, but may be softened by placing in hot water.

Photographic positives made upon ivory or upon ivorine have a very delicate appearance. These are best made by coating the ivory with a gelatine or collodio-chloride of silver printing-out emulsion, and printing, toning, and fixing in the ordinary way.

In the earlier days collodion positives were made upon ivory, dyed black by boiling first in a decoction of logwood, and then in a solution of red acetate of iron; or violet, by first boiling it for a little while with proto-chloride of tin, and then in logwood.

IVORY BLACK.—A species of bone black made by the calcination of ivory scrap turnings, sawdust, &c. It is used as a pigment in the manufacture of paints, varnishes, &c.

IVORY PAPER.—A superior paper, having a finely-prepared and polished surface.

IVORYTYPE.—An American term for a kind of picture, in which two finished photographs are taken, one light in color, made translucent by varnish tinted on the back, and placed over the stronger picture so as to give the effect of a photograph in natural colors. Also known as *Hellenotype.*

JAPAN VARNISH.—A hard black varnish obtained from the *Stagmaria verniciflua* of the East Indies. An asphaltum varnish. (See **Varnish.**)

JAVELLE WATER.—See **Eau de Javelle.**

JENA GLASS.—A new optical glass manufactured at Jena. According to Mr. Conrad Beck, the advantages of the new glass largely depend upon the fact that, whereas previously we had some dozen or so different kinds of glass, all more or less similar in their refractory qualities, we have now offered to us by the Jena glass factory some ninety kinds of glass, all possessing refractory powers, and some of which have entirely new qualities.

JEW'S PITCH.—See **Asphaltum.**

KALLITYPE PROCESS.—A printing process giving a dull matt-surfaced picture, similar to platinotype or bromide paper. The formula for the manufacture of the paper is not published The paper is, however, sold commercially.

The paper is much more sensitive than ordinary albuminized paper; it will, therefore, be necessary to see that all operations with it, such as cutting up, placing in the printing frames, developing, etc, are all conducted either in yellow or in very weak daylight. It should be kept guarded from light and moisture.

Printing.—Kallitype may be said to be a combination of a printing-out and a developed process, as the image prints out visibly, but is not sufficiently brilliant until treated with a devel-

oping agent, which has the effect of bringing up the image bright and clear, provided the exposure has been correctly given. When placing in the printing frame it is necessary to see that the paper is quite dry, otherwise the correct exposure cannot so easily be determined, and the print will also lack brilliancy in color. When the air is very moist it will be advisable to dry it carefully. It must not, however, be made too warm, or it will produce fog. In a good actinic light, with a correctly exposed and developed negative, about five to ten minutes will be found necessary, in sunlight only about two or three minutes. The image can be examined, but is rather faint. As soon as the detail in the densest part of the negative appears it has been sufficiently exposed, and may be removed.

Developing.—The prints (which must be quite dry) are floated face downwards upon the following solution:

Nitrate of silver	50 grains
Sodium citrate	1 ounce
Potassium dichromate	1 grain
Tap or rain water	10 ounces
Ammonia .880	½ drachm

This is made up by dissolving the silver nitrate in about an ounce of the water, and the sodium citrate and potassium dichromate in the remainder, and the two solutions thus formed are mixed together. The ammonia is then added, and the whole filtered.

Upon this solution the prints are floated for from ten to twenty seconds, after which they are placed face upwards upon a piece of clean glass for two or three minutes, in order to gain density. They are then immersed in washing solution No. 1, composed of

Kallitype developer (as above)	½ ounce
Sodium citrate	2 ounces
Rain or tap water	20 ounces

This solution can be used over and over again. In it the prints must remain for at least twenty minutes, a longer fime will not hurt them. The object of this solution is to remove the yellow color from them.

The developed prints are next washed in a solution made up with

Sodium citrate	1 drachm
Ammonia .880	2 drachms
Tap or rain water	1 quart

for about ten minutes. The solution is then poured off, and the prints treated with a fresh supply. This solution, after the prints have been in it for about ten minutes, should not show any sign of yellowness. If so, a fresh supply should be taken, otherwise the prints will be yellow. The print should be kept moving in the different baths, and after the last they are removed, washed for a little time in water, and dried.

The correct exposure of the print can be seen in developing. When it has been insufficient the action of the developer will be very slow. If over-exposed the prints will appear mealy, and when much overdone they will develop very heavy and muddy.

The developing solution can be used over and over again, until it loses its power and the prints lack brilliancy. It can then be restored by adding to every 10 ounces of it, 20 grains of silver nitrate dissolved in as little water as possible.

The following should be noted. Prints, when not developed the same day as printed, must be kept quite dry or they will suffer. The washing solution used at the end should always have a distinct smell of ammonia. In printing from weak negatives additional contrast may be secured by adding a little more of the potassium dichromate to the developer. A stock solution, made up of 8 grains to the ounce of water, should always be kept on hand, so that a little may be added when required. One drop of this added to 10 ounces of developer will give greater brilliancy and contrast.

KINETOGRAPH.—See **Chronophotography.**

KINETOSCOPE.—See **Chronophotography.**

KNIFE, CUTTING.—See **Trimmer.**

KAOLIN (synonym, China clay).—A celebrated porcelain clay of China. It is very pure and white, and is furnished by the decomposition of a granitic rock, the constituents of which are quartz, felspar, and mica. The felspar gradually disintegrates into this substance. It is used in photography for cleaning and removing grease from glass, and in the collodion process for decolorizing discolored nitrate baths and other solutions. A small quantity is added to the solution and shaken well up. It is then allowed to settle, and the clear liquid decanted. For this purpose the kaolin must be quite free from iron. If its presence is suspected, test by boiling a small quantity with hydrochloric acid, neutralize the acid liquid with ammonia, and add potassium ferrocyanide. If iron be present, a blue precipitate will form. Chalk and whiting adulterations can be detected by effervescence when treated with hydrochloric acid.

KILO OR KILOGRAMME.—A measure of weight according to the metric system. It is equivalent to 1000 grammes or 2.2046 pounds avoirdupois.

KREOSOTE.—See **Creosote.**

LACQUER.—A varnish chiefly composed of an alcoholic solution of shellac, colored with gamboge, dragon's blood, etc. The formula is—

Seed lac	120 parts
Gamboge	120 parts
Dragon's blood	120 parts
Saffron	39 parts
Rectified alcohol	1000 parts

Digested in a convenient vessel, with heat, and strained through fine muslin.

LAMP.—The various lamps used in photography are dark-room lamps, portable non-actinic lamps for travelling and exposure lamps.

The chief points to be observed in a dark-room lamp are that it shall give an non-actinic light, and not allow any stray light through any of its joints or parts. Its color depends upon the stained glass through which the light is transmitted. The best lamps are those in which the glass can be changed, or another piece inserted so as to allow the operator to work conveniently, and with safety, with very sensitive dry plates, or with much less sensitive bromide or chloride paper. Other desiderata are in simplicity of construction, and in its cleanliness and ease of management. Fig. 227 is a sketch of a lamp devised by Carbutt, and possesses many conveniences, such as a shade to protect the eyes, and a side-door for exposing or viewing the negative.

With regard to the best non-actinic media that should be used for dark-room lamps, it depends, naturally, upon the sensitive materials that one is working with. The property of light to affect sensitive compounds will be found under the article relating to light. (See also **Spectrum.**)

With regard to the second class of lamps, *i.e.*, those useful for tourists, it needs only to be said that the chief desideratum is in portability and bulk. A very large quantity have been constructed which answer the purpose well, and when not required for use fold up into a very small space. Figs. 227–228 are very convenient forms of lamps. The latter is especially suitable for tourists as it can be folded up so as to occupy a very small space. Very fine portable electric dark-room lamps are now manufactured, and are to be recommended in warm weather, when the air in the dark room usually gets very hot and close.

The third class of lamps, *i.e.*, those used for exposing in making or exposing negatives, are principally the electric lamp, magnesium lamp, and flash lamp. (See **Electric Light, Flash Light,** and **Magnesium Light.**)

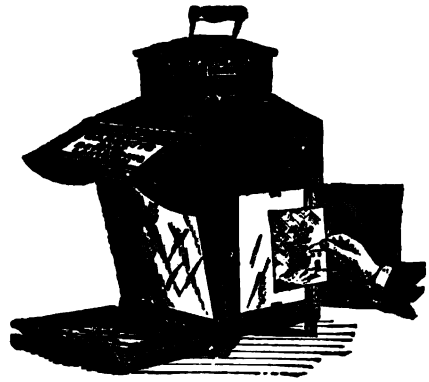


FIG. 227.—DEVELOPING LAMP.

LAMPBLACK.—A fine carbon, formed by the condensation of the smoke of burning oil, pitch, or resinous substances, in a chimney terminating in a cone of cloth.

A conical funnel of tin, covered over with cloth, and fitted with a pipe to convey the fumes from the apartment, is suspended over a lamp fed with oil, tallow, coal tar, or crude naphtha, the wick being large and turned up high so as to give a smoky flame. The soot collects in the funnel, and is removed from time to time.

Lampblack is the basis of Indian ink, printers' ink, and most black colors.

It is principally used in photography for coloring gelatine for the carbon or Woodburytype process. This color being permanent, the prints by this process are also unchangeable.

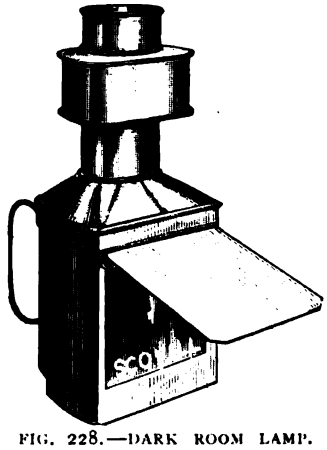


FIG. 228.—DARK ROOM LAMP.

LANDSCAPE LENS.—See **Lens.**

LANTERN.—See **Optical Lantern.**

LANTERNOSCOPE.—An instrument devised by Tylar, of Birmingham, for viewing lantern slides. The lantern slide is inserted through an aperture in the side, and is examined through a small magnifying glass in the eye tube in front.

LANTERN PLATES.—Usually chloride of silver emulsion plates used for making lantern transparencies.

LANTERN SLIDES.—See **Transparency.**

LATENT IMAGE.—The name given to the "latent" or invisible image, resulting from the impact of light upon the sensitive photographic plate. This image, although invisible to the eye, quickly becomes perceptible when treated with a reducing agent termed a developer.

FIG. 229.—PORTABLE DARK-ROOM LAMP CLOSED.

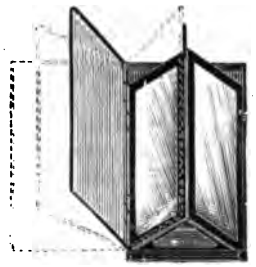


FIG. 230.—PORTABLE DARK-ROOM LAMP OPEN.

The theory of the latent image is surrounded in mystery. Many attempts to solve it have been made by a number of eminent chemists and scientists. The results of numerous experiments regarding the acton of the light upon silver compounds show that when in a vacuum pure silver haloids do not become decomposed by light at all, but if moisture be present a change takes place with the silver bromide or chloride, and a dark-colored compound containing a lower percentage of the halogen than contained in the original salt, a substance also being formed having the power of liberating iodine from potassium. The dark solid product has never been clearly explained. It is generally considered to be a sub-bromide or sub-chloride, but many scientists dispute this.

One of the first theories of the latent image was that the action of the light upon the sensitive salts was to set up a vibratory motion. Although this theory is still considered the correct one by a few, the experiments of Abney, Bothamley, Meldola, Carey Lea, and others, clearly prove it to be erroneous.

Chemically the action of the light is expressed thus—

Silver Bromide.			Silver sub-bromide.	Bromine.
$2AgBr$	+ light	=	Ag_2Br	+ Br

The following remarks are mostly taken from an excellent summary (by Mr. C. P. Bothamley, F. I. C.)* of what is already known about the matter:

The physical theory of the latent image assumes that the energy of the light rays is transferred to the molecules of the silver haloid, which are thereby thrown into a state of unstable equilibrium such that the compound is reduced to the metallic state by reagents which, under normal conditions would have no action on it. The chief evidence in support of this view was the observation that the latent image spontaneously disappeared. There is, however, a considerable amount of evidence to show that the latent image does not fade spontaneously, but, in all cases where its disappearance is observed, it is destroyed by the action of atmospheric impurities, or by secondary reactions with substances retained in the film. Carey Lea showed that silver iodide will absorb free iodine, and hence the gradual disappearance of the latent image on Daguerreotype plates, or any of the films obtained by treating silver with an iodizing agent, may be traced to the fact that the silver iodide has absorbed an excess of iodine during its preparation, and this iodine gradually acts upon the product of the action of light and re-converts it into normal silver iodide.

Analogy would lead us to expect that if the silver haloid were thrown into an unstable condition by the action of waves of light, it would gradually and somewhat rapidly return to its normal condition when the disturbing cause ceased to act. Gelatino-bromide plates have been kept two or three years after exposure, without any reduction in the character of the image on development. It is in the highest degree improbable that that a mere *condition* of unstable equilibrium would persist for so long a time, and these facts, combined with the fact that the latent image is destroyed by reagents of a particular kind, but not by others, seems to be conclusive against the physical theory.

All evidence indicates that the formation of the invisible image is a photo-chemical operation, the composition of the material forming the image being different from that of silver bromide. The difference between the formation of a visible image and a latent image is a difference in degree, and not in kind.

Bothamley further remarks that it seems that it has not been clearly recognized that the formation of a developed photographic image takes place in three distinct stages, which may, and probably do, differ considerably in the nature of the changes which occur. First, we have the *latent photo image* formed solely by the action of light, and therefore of photo-chemical origin; secondly, we have what he calls the *primary* or *fundamental image*, formed by the latent image by the action of the developer, and, therefore, partly of photo-chemical and partly of chemical origin; and, thirdly, the *developed image*, formed by the action of the developer from the primary image and the unaltered silver bromide in the film. This last process is probably mainly electro-chemical. It has not yet been definitely proved that the material composing the latent image is identical in composition with the visible products formed by the more prolonged action of light, although the various known facts furnish very strong proof that this is the case.

The results of the experiment seem to be in a point being reached that the latent image is a photo-mechanical reduction product containing a lower proportion of halogen than normal silver

* *British Journal*, 1890, p. 235.

chloride, or bromide, or iodide, and much more easily reduced to the metallic state. The problem of its composition and constitution still remains to be solved.

LATITUDE OF EXPOSURE.—This term is applied to the extent of deviation possible either way from the exact exposure necessary without affecting to any harmful degree the character of the image.

The amount of latitude in exposure naturally varies with the sensitive media employed. With highly-sensitive plates requiring exposures of the fraction of a second, very little latitude is permissible unless the subject be a very dark one, or a very small diaphragm be employed.

With ordinary plates more latitude is permissible than is usually imagined, although it is always advisable to err on the side of over rather than under exposure.

LAUREL CAMPHOR.—See **Camphor.**

LAVENDER OIL.—Several species of *Lavandula* are cultivated for the sake of this oil. The plants of *Lavandula vera* are clipped before flowering, and treated with phosphate of lime. They are then distilled, and oil of lavender is obtained. The *Lavandula spica* affords an inferior product, termed oil of spike, much used by painters on porcelain, and for varnishes.

Lavender oil, or oil of lavender, as it is more commonly termed, is a thin, pale yellowish liquid, with a very pleasant odor resembling the lavender flowers. It is insoluble in water, but dissolves readily in alcohol.

It is used in photo-mechanical processes, chiefly as a solvent for asphaltum, also as a perfuming agent in encaustic pastes, and a solvent of pyroxyline in the manufacture of vitrified enamels. When added to shellac varnishes, a larger quantity of the lac can be dissolved.

LEAD (Symbol, Pb; atomic weight, 206.4).—A gray and very soft metal, soluble in nitric acid. It is very useful for lining wooden tanks or in making dark-room sinks. Hypo will not affect it so that leaden fixing tanks can be employed. Where leaden sinks or leaden pipes are employed, however, it will be necessary to prevent acids from being thrown down. Lead forms several salts, some of which are used in photography.

LEAD ACETATE (Formula, $Pb(H_3C_2O_2)_2 + 3H_2O$; synonyms, *acetate of lead, sugar of lead, plumbic acid*).—Prepared by dissolving carbonate of lead in a dilute solution of acetic acid. It is then purified and formed into white crystalline masses, with an odor resembling vinegar, and rather a sweetish taste. Ten parts of it are soluble in 25 parts of water, or 80 parts of alcohol. It gives a milky solution, which can be clarified with the addition of a little acetic acid. A dilute solution has been recommended for use as a method for eliminating the sodium hyposulphite from the film, but the advantage of its employment is rather doubtful, as a compound of lead thiosulphate would be formed in the film, a substance which blackens in the presence of sulphuretted hydrogen contained in the atmosphere.

LEAD CHROMATE (Formula, $PbCrO_4$; synonyms, *chromate of lead, chrome yellow*).—Prepared by mixing dilute solutions of lead acetate and potassium chromate. It is largely used in painting as *chrome yellow*, and as a coloring matter in the manufacture of fabrics for dark rooms. It is not to be recommended for this purpose, as it changes by the action of the atmosphere. It also serves the analyst as a source of oxygen for the analysis of organic bodies, for the reason that when heated it fuses into a brown mass, which evolves oxygen at red heat.

LEAD INTENSIFIER.—See **Intensification.**

LEAD NITRATE (Formula, $Pb(NO_3)_2$; synonyms, *nitrate of lead, plumbic nitrate*).—Crystallizes in opaque white octahedral crystals from a solution of lead, or its oxide, in dilute nitric acid. It dissolves readily in about eight times its own weight of water, hardly soluble in alcohol, and insoluble in nitric acid. Mixed with potassium ferricyanide it forms a powerful intensifier for wet plates, as the solution thus formed converts the silver image into lead ferrocyanide and silver ferrocyanide, the potassium and the nitrate combining to form potassium nitrate.

LEAD TONING BATH.—An acetate of lead toning bath has been recommended for silver printing-out papers. The formula is:

Lead acetate	15 grammes
Sodium hyposulphite	120 grammes
Distilled water	20 onnces

It should be stated that the toning action here is due to sulphuration, and the life of the prints is likely to be of very short duration.

LEAST CIRCLE OF ABERRATION.—The smallest section possible to make in the cone of rays of light emergent from a lens. In practice it is the most perfect focus that it is possible for parallel rays of light to have.

LEAST CIRCLE OF CONFUSION.—See **Aberration.**

LEIMTYPE.—A process invented by Husnik, of Prague, by which gelatine images in high relief are used for direct printing from in the ordinary letter printing-press. A thick plate of chromatized gelatine is exposed under the negative. This is then attached by means of gutta-percha to zinc or wood. The surface is then developed by means of a solvent such as a saturated solution of an alkaline bichromate. This not only dissolves those parts unacted upon by the light, but also strengthens the relief. After development, and before the fine lines and dots are injured, the plate is dried, and the lights are covered with an opaque printer's ink by means of a camel-hair brush. The plate is then exposed for a second time to the action of the light, by which it is hardened and strengthened. The plates thus produced may be used in the ordinary printing-press with letter-press, and as many as 50,000 copies may be taken. Electrotypes can also be made in the usual manner.

LENGTH OF FOCUS.—See **Focus.**

LENS.—A lens is a transparent body, usually glass, so shaped as to afford two regular opposite surfaces, both spherical, or one plane and the other spherical, constructed for the purpose of concentrating or scattering rays of light transmitted through it.

It would be a very difficult matter to determine when lenses were first made. Although their use has been traced to the Chinese moralist Confucius 748 B.C., it is possible that they were made and used many years previous to that date. A glass case in the Assyrian section of the British Museum contains a piece of rock crystal formed into the shape of a plano-convex lens 1½ inch in diameter, and $\frac{9}{10}$ inch thick. This was discovered in the ruin called Nimroud. It gives a focus of 4½ inches. According to Sir David Brewster, this lens has been designed for magnifying purposes. The date is about 700 B.C. Plutarch speaks of instruments used by Archimedes "to manifest to the eye the largeness of the sun." Euclid's treatise on "Optics" appeared about 280 B.C. Other notices of lenses may be found scattered through the pages of antiquity, until the revival of science and learning in the twelfth century, when Alhazen is credited with having written on the refraction of rays and the magnifying power of lenses. Vitellus, a Pole, also wrote a treatise on lenses about 1270. The first lenses of which it is possible to discover any reliable record are those invented by the Florentine Salvine degli Armati, who died 1317. The invention of spectacles has, however, been credited to Roger Bacon (1250), but Pliny mentions that Nero, who was myopic, used glasses when he watched the fights of the gladiators.

Baptista Porta (1560) the inventor of the camera obscura, states: "If you know how to combine a convex and a concave glass, one of each sort, you will see far and near objects larger and clearer."

Passing over a period during which but little improvement was made in the manufacture of lenses, we came to the time of John Dolland (born 1706, died 1761). This celebrated optician was the son of a French refugee, a silk weaver at Spitalfields. His improvements in the manufacture of lenses are well known, and he it was who discovered the method of achromatizing lenses by combining glasses of different dispersive powers, completely upsetting Sir Isaac Newton's statement in his "Optics" "that all refractory substances diverged the prismatic colors in a constant proportion to their mean refraction," and consequently, "that refraction could not be produced without color," and for that reason no improvement could be expected in the refractory telescope.

Many and great were the difficulties experienced in obtaining lenses homogeneous and free from striæ. The Paris Academy of Sciences offered several prizes, and subsequently a commission, consisting of Herschel, Faraday, Dolland, and Roget, were instructed to pursue the inquiry. Knight says of the result of this commission: "The excise system of England at that time sat like a foul bird on all the nests where glass was hatched and prevented the experiments, tying the hands of the noble quarternion of philosophers with a few yards of red tape applied by some seedy looking individual with a pen behind his ear and no speculation in his eye." Munich carried off the palm, and later on in the year 1851 pure discs of flint glass were exhibited in London, having a diameter of 29 inches, and weighing 224 pounds.

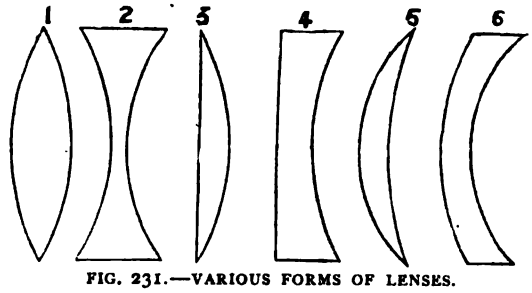


FIG. 231.—VARIOUS FORMS OF LENSES.

In the earliest days of photography telescopic objectives were employed, but the importance of the discovery soon led to the manufacture of special lenses for the purpose. A large number of different kinds have been constructed, the most important of which will be described later on.

The glass used for the manufacture of lenses is usually "crown" or "flint." Some account of its manufacture will be found under **Glass.** The difficulties of obtaining discs of large dimensions perfectly free from striæ, have been partly overcome.

These discs are cast or ground with sand into something near the shape they will subsequently be formed into, and which is determined by careful calculations. These forms are here

given. No. 1 is a bi-convex; No. 2, is a bi-concave; No. 3, a plano-convex; No. 4, a plano-concave; No. 5, a meniscus; No. 6, a concavo-convex. The tools for grinding them must possess the same radii of curvature which the surfaces of the lens are to have. For this purpose an arc of a circle double the diameter of the tool is drawn on a plate of copper made very flat by hammering, and followed up very carefully with a file, so, as to have an exact shape.* Two of these are made, the one convex and the other concave. The convex or converging lenses are thicker in the middle than at the edges, and the concave or diverging lenses are thinner in the middle than at their edges. A double convex lens may be regarded as composed of two prisms, having their bases outwards, and their edges meeting at the center.

FIG. 232.—TOOL FOR GRINDING LENSES.

The tool employed for the grinding and shaping of these lenses from the roughly-shaped disc of glass is shown in fig. 232. This is cast from a wooden model, and finished in a lathe. The two gauges are thus rubbed one on the other to give them accurately the curve which they must have. These gauges are applied against the tools A and B (fig. 232) whilst they are being worked in the lathe. When the tools are thus finished they are rubbed together with emery until they touch at each part. The object of having two tools, A B, is that during the grinding the one used loses its surface slightly, and requires to be ground in a similar way upon the other to restore it to its primitive curvature.

The piece of glass is chipped round the edges in a circular form by means of flat pliers of soft iron a little larger than the diameter the finished lens is to be. It is then attached with soft pitch to a brass plate rounded in the lathe in such a manner that the glass adapts itself to it as closely as possible. The tool A or B (according as the face of the lens is to be convex or concave) is fixed in a solid block and headed with a little moistened fine emery. The lens attached to the plate is then moved about in the tool with more or less pressure. After the emery powder has done its work, and the glass touches every part of the tool, the emery is changed, and the finest kind procurable is used to retouch the tool A (if that be the one used) with B, to preserve the correctness of its surface. The points to be observed in grinding are that the lens does not go beyond the tool, which must be somewhat large, that the emery powder be kept always moist, and that the lens be moved about in all directions and not for any length of time in one. After the emery powder, fine pumice-stone is used. The lens is then detached from the plate, reversed, and the opposite side worked in the same manner. The lens, if properly ground, should have perfectly spherical curvatures. The next process is that of polishing without altering these spherical surfaces, a by no means easy process. The following method of polishing is described by Monckhoven:—A melted mixture of equal parts of resin and pitch is passed through linen. The tool is gently heated, and the preceding mixture (somewhat cooled, so that it may have lost its previous fluidity) is spread over it in sufficient quantity to cover it to a thickness of three or four millimetres. The resinous mixture is spread in a uniform layer by means of the other tool, which, for this purpose, ought to be very cold and thoroughly clean. The first tool is then plunged into cold water to harden the resinous mixture. A little very fine rouge is spread over the surface and the lens carefully polished by proceeding in the same way as for the smoothing previously described until the operation is completed. It is necessary to take care that the glass does not get hot, and to exert a uniform pressure with the hand all over the surface of the lens, otherwise certain parts of the surface will be polished before the others, and the surface thus loses its sphericity. Lenses having convex surfaces are the easiest to work, convergent and divergent meniscus lenses the most difficult.

The ground and polished lenses have next to be centered and mounted. The centers of the two surfaces of the lens, are then in the same sight line perpendicular to the circumference of the lens. If the lens is less than two inches in diameter it is attached to the latter with mastic as centrally as possible, and the latter revolved. The reflected image of a candle flame placed at some distance is then observed. If the lens is properly centered the two images produced by the two surfaces should not be displaced from each other. If improperly centered one or both of the images will discribe a circle. The lens in this case requires to be moved until the center is perfect and the images remain motionless. The margin of the lens is then ground with copper and emery, and it is ready for mounting in the brass tube either by fixing it permanently, when it is said to be set, or by fixing it into place by means of a second ring which can be unscrewed at will.

Combination lenses are formed by cementing two or more together. This is done by slightly warming and placing a drop or two of Canada balsam upon the surface. The two lenses are then tightly pressed together, squeezing out as much as possible of the excess of balsam. When cooled they have the appearance of one piece, and can only be separated by heat. If, however, the two lenses have not a common surface, two or three small pieces of tin-foil are introduced at equal distances apart between the margins, or, if further separation is required, a brass ring is inserted between them.

Having now briefly described the manufacture of convex and concave lenses, it will be

* Monckhoven's "Optics."

necessary to consider the methods by which they are employed for photographic purposes.

To do this it will be well to go back a little into the theory.

When a ray of light travels through any transparent medium it preserves a straight course, provided the density of the medium remains the same; but if the density varies, either by becoming greater or less, this ray of light is immediately *refracted* or bent out of its course, and pursues a different direction. The amount of refraction depends upon the nature of the medium and its density as compared with the one through which the ray had previously travelled. It must not be omitted to mention that this law only applies to rays of light falling upon the medium at an angle, and that deflecting power is at the surface of bodies. Fig. 233 will explain this. A ray of light falls at an angle upon the medium denser than the air. It is refracted at the surface and pursues another straight course until it leaves the denser medium, when it is again bent, the usual law of bending towards the perpendicular on entering, and away from it on leaving, being carried out. If the ray enters perpendicularly in the direction of the dotted lines no refraction takes place, and it passes straight through.

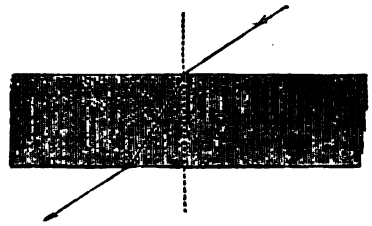


FIG. 233.—RAY OF LIGHT PASSING THROUGH A TRANSPARENT MEDIUM.

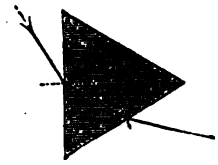


FIG. 234.—GLASS PRISM

It will be clearly seen that by modifying the surfaces of the refracting media the rays of light may be diverted in almost any direction at will. A glass prism (fig. 234) bends the ray of light to one side. By placing two such prisms base to base parallel rays may be made to meet at a point (see fig. 235), and conversely if they be placed together at the summits (see fig. 236) the effect will be to separate them farther away from each other. This same effect is obtained with lenses having curved surfaces as with these prisms. The assimilation of lenses to prisms will be clearly seen on reference to figs. 237, 238, 239 and 240. A convergent lens may, therefore, be described as formed of two prisms united at the base, and a divergent lens as of prisms united at the points. The former causes the rays of light to converge and meet at a point, and the latter makes them diverge farther away.

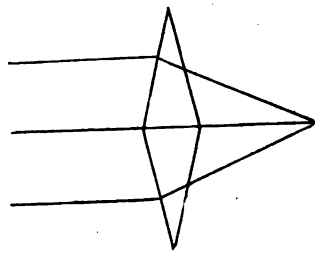


FIG. 235.

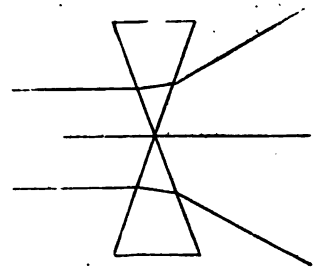


FIG. 236.

To better compare the path of a luminous ray in a lens with that in a prism the surfaces of the lenses are supposed to be formed of an infinity of small plane surfaces or elements. (See fig. 241).

The normal at any point is then perpendicular to the plane of the correspondent element. It is a geometrical principal that all the normals to the same spherical surface pass through its center. Upon the above hypothesis it is always possible to conceive two plane surfaces at the points of incidence and emergence which are inclined to each other and produce the object of a prism.

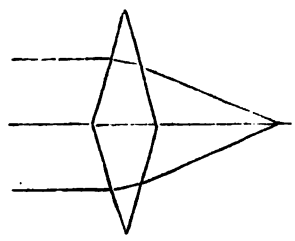


FIG. 237.

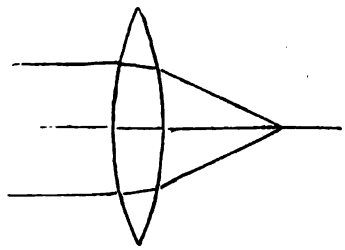


FIG. 238.

Placing aside for a while the different aberrations that lenses are guilty of, we can consider the effects produced. Supposing a pencil of parallel rays falls upon the surface of a diverging lens, the rays will all be concentrated to a point on the other side of the lens. (See fig. 242).

This point is termed the focal point, or principal focal point, and its distance from the center of the lens is referred to as the focal length of the objective employed. This point remains unchanged. When the rays are not parallel, but diverge from a luminous point, that point is associated with the focus. If the luminous point be moved farther from the lens, the transmitted rays will converge to a point, and when it is twice as far from the lens as the principal focal point, the point of light produced on the other side of the lens will be at exactly the same distance from the lens. Any two such points are called conjugate foci (*q. v.*). Now, the object of a

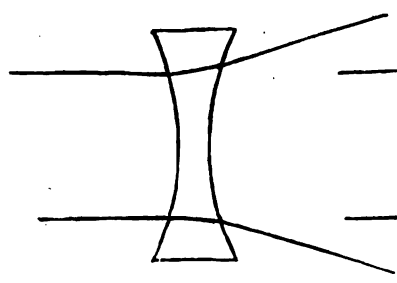


FIG. 239.

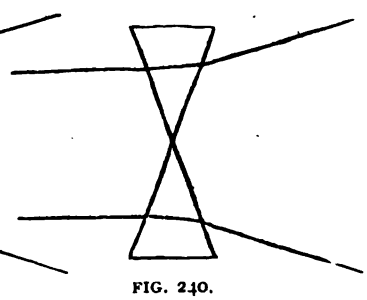


FIG. 240.

photographic lens is to produce an image upon the ground glass of the camera, or upon the sensitive medium. The manner in which it does this will not now be so difficult to understand. It brings the rays of light proceeding from a point to a focus, and an image of the object is the result. If the object be placed at some distance in front of the lens, an image will be formed smaller than the object itself, but if the object be brought nearer to the lens the image will increase in size, and the focus will at the same time recede to a greater distance. But if brought nearer than a certain point, the lens will be what is termed "strained," and the image will become dreadfully distorted. It is for this reason that long focus lenses are specially constructed for obtaining large images. These have usually a large diameter, but it must be remembered that the diameter or size of the lens has nothing whatever to do with the size of the image.

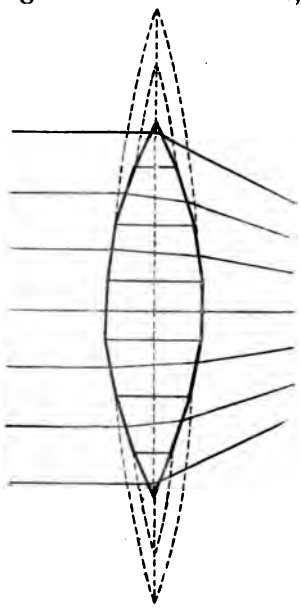


FIG. 241.—SHOWING COMPARISON BETWEEN A LENS AND A NUMBER OF PRISMS.

The rays of light proceeding through a converging lens from an illuminated object cross each other without interference when emerging from the other side, as seen in fig. 243, so that the image is necessarily inverted, and appears upside down on the focussing screen.

From this sketch it will also be seen that the rays which traverse the central point of the lens or the center of the axis, as it is termed, are not bent away, but pursue a course either coincident with or parallel to the original.

Now the image produced by a lens is, unfortunately, subject to many defects, principally termed "aberrations." Under that heading these defects and the manner in which they have been partly overcome are clearly explained. It will, however, be convenient to mentioned them here. The principal defect, then, is termed chromatic aberration. The effect of this is that the rays of light passing through the lens become decomposed into their constituent prismatic colors, and the image on the screen is bordered by colored fringes. At the same time the visual and chemical foci are separated. Now, for photographic purposes, it is necessary that these rays should be united, so that when a sharp image is seen on the focussing screen an equally sharp image will be produced on a sensitive plate placed on the same plane, technically known as working to focus, or having the visual and chemical foci coincident. The manner in which this defect is remedied is simple enough. Two lenses are placed together having different dispersive power, the one being of crown and the other of flint glass. Now, separately, both these lenses possess the defect of chromatic aberration, but in an opposite manner, so that the two combined completely neutralise each other, that is to say, sufficiently for photographic purposes. The absolutely perfect correction of chromatic aberration has never yet been accomplished. All lenses now manufactured for photographic purposes (except the very commonest kind) are made *achromatic*. Another common defect in lenses is spherical aberration, caused by the refraction of the rays of light unequally at different portions of their surfaces. The method of correcting this defect is by the use of suitable curves, and lenses so corrected that it is possible for them to be employed with full aperture are termed "aplanatic," although this word does not seem to be properly understood, as it is often used in a very vague or incorrect sense. Spherical aberration can also be overcome to a very great extent by placing a diaphragm or stop in front of the lens.

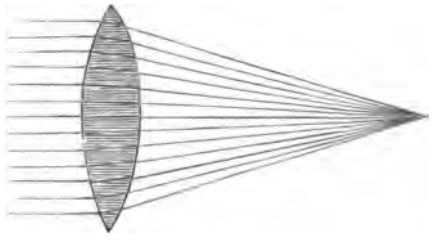


FIG. 242.—A CONVERGING LENS.

Thus we see that what is required in a photographic lens is one that shall give a perfect image, free from defects or distortion, and having its visual and chemical foci coincident. Besides these points, there is the question of rapidity or brilliancy of the image. This is dependent chiefly upon the aperture or light gathering capacity of the lens forming the image, and the area over which the latter is spread. The amount of light gathered by the lens being proportional to its working aperture, and the area of the image being proportional to the square of the lens focus, the brilliancy of the image varies directly as the area of its working aperture, and inversely as the square of its focal length. Upon the brilliancy of the image depend the rapidity of the lens, and the briefness of the exposure necessary. A certain amount of loss of light will, however, occur in all lenses, due to absorbtion and to reflection of the

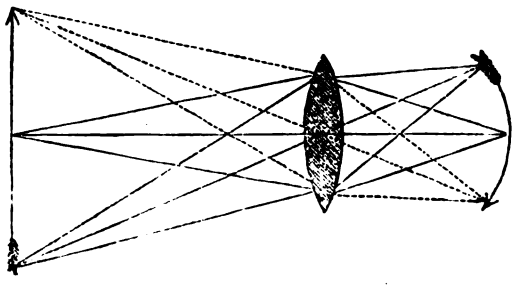


FIG. 243.
SHOWING THE PATH OF THE RAYS THROUGH A LENS

glass surfaces. Single lenses possess the advantage over all others of occasioning less loss of light from these causes.

We will now go back to the earliest days of photography, and see what has been done towards obtaining a lens answering to these requirements.

In the camera obscura of Porta a double convex lens was always used to throw the visible image upon the glass, but when the discoveries of Daguerre, Niepce and Talbot were announced, and photography became an accomplished fact, it was discovered that this lens was exceedingly defective, and mathematicians and opticians strove to obtain one that should be more perfect, and with which the visual and actinic foci should coincide, which was not the case with the double-convex lens.

Eventually this single lens was replaced by the achromatic lens that had long been used for the telescope; but this was also very imperfect, as the requirements for photographic purposes were very different from those for the telescope. The function of an object glass of a telescope is to produce images of objects transmitted axially, or in near approximation to the axis, while a photographic lens is not only required to do this, but must also collect rays transmitted at considerable obliquity to the axis, and to project them to distances proportionally greater than the axial ones, in order to give a flat field. The rays that pass obliquely through a telescope are not used, but in the camera these oblique rays generally form by far the greater part of the image. The achromatic lens first used is shown in Fig. 244. Owing, however, to the circumscribed area of definition the lens was reversed, the plane side being presented to the object, as shown in Fig. 245, the arrow indicating the direction of the light.

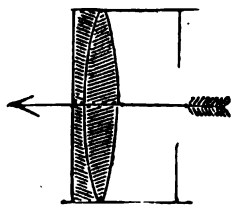


FIG. 244.

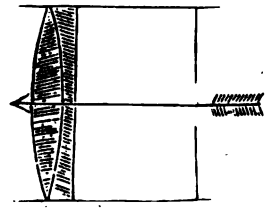


FIG. 245.

But attempts were then made to secure a wider aperture, so that greater rapidity would result. A larger and flatter field was also considered desirable.

About the year 1840 Wollaston's meniscus (Fig. 246) became to be recognized as a means of securing an extended field, and later on in the same year Chevalier, a Parisian optician, made many further improvements in its illumination by combining two achromatic lenses.

In the following year, however, the greatest discovery in photographic appliances was made by Professor Petzval, of Vienna, and Voightländer constructed under his directions the Petzval portrait lens. According to J. Trail Taylor, the late Voightländer, a year after Daguerre's discovery, when calling upon Professor Von Ettinghausen, was asked by that gentleman whether he could determine the refracting and dispersing powers of different descriptions of crown and flint glass, as Professor Petzval, who was at that time filling the mathematical chair in the Vienna University, had made the calculation of a photographic lens which could not be executed in consequence of the quality of the glass to be employed not being then in existence. Voightländer, intimating his ability to do this, was requested to call immediately upon Professor Petzval, and was given a letter of introduction to that gentleman, accompanied by the observation that by furnishing the means to execute this lens he would render great service to the world, and secure a great reputation for himself. The result of the ensuing interview was that Voightländer furnished the desired information respecting the qualities of the various glasses, which formed the foundation of the calculation of two combinations of lenses executed by Voightländer, one being the well-known portrait combination in use to the present day, and the other the orthoscopic lens not introduced to the public notice until 1857.

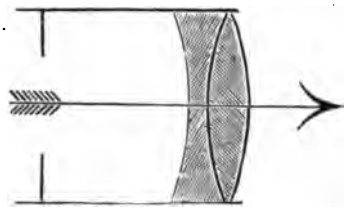


FIG. 246.—WOLLASTON'S MENISCUS.

The portrait lens was issued about the year 1841—fig. 247 will serve to show its construction.

The converging lenses are of crown and the divergent lenses of flint glass. The front combination consists of a double-convex crown glass lens cemented to a double concave of flint glass, and the back combination is a flat glass concavo-convex separated from a double-convex crown glass lens by a brass ring. The negative refractive power of the flint glass concavo-convex lens is sufficiently strong as to balance the positive aberration of the whole combination. A number of modifications of this lens have been introduced, but are all constructed on the same principle.*

The focal lengths of the posterior and anterior combinations are as three to five, and the combinations are separated a distance about equal to half the equivalent focus of the lens itself.

* These terms *aplanatic* and *aplanatism* are somewhat misapplied, and cannot, strictly speaking, be applied to photographic lenses. They were originally employed by Dr. Blair in 1791 to lenses free from spherical aberration. It is now popularly applied to any lens that will give sharp central definition when working with full aperture. This, however, even an imperfectly corrected lens will do if its diameter be sufficiently reduced.

The chief feature about this lens is its great rapidity, obtained by shortening the focal length and using the full aperture without a diaphragm.

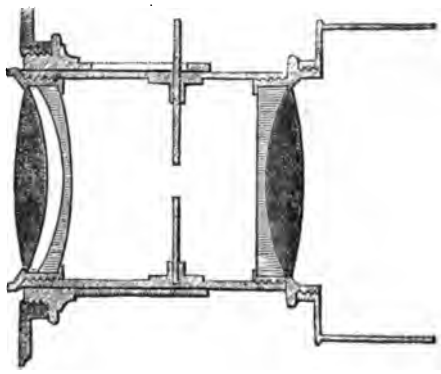


FIG. 247.—PORTRAIT LENS

The year 1858 saw several improvements in photographic optics. Grubb introduced his patent aplanatic lenses. In these he obtains a deeper separation curve between the components of the single lens, making the crown lens a meniscus, and placing it in front instead of behind the flint. The effect of this deeper separating curve, Grubb claimed, was that the spherical aberration was nearly corrected, and consequently one was enabled to use a much larger diaphragm than previously possible. Fig. 248 is a sketch of this lens.

In the same year Petzval introduced his new landscape lens. It was made under his directions by Dietzler, of Vienna, some disagreement having taken place between Petzval and Voightländer since they had united their efforts to produce the portrait lens. The fame of the first Petzval lens secured a warm and welcome reception for this new one, and it was instantly copied by opticians in all countries and sold under various high-sounding names, such as caloscopic, orthoscopic, etc. The accompanying sketch, Fig. 249, shows the construction of this lens, and Fig. 250, a modification by the American optician, Harrison.

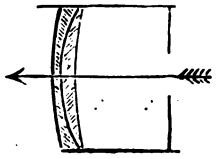


FIG. 248. GRUBB'S APLANATIC.

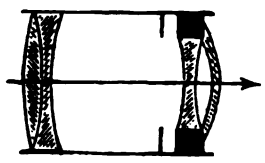


FIG. 249. PETZVAL'S LANDSCAPE LENS.

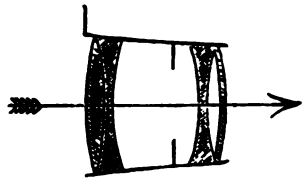


FIG. 250. HARRISON'S LANDSCAPE LENS.

In the next year (1860) Deway introduced a *multum in parvo* lens, having in the one instrument three view and three portrait lenses, the changes being made by bayonet joints. This method has also been adopted by several other opticians.

In this year also Sutton took out a patent for his panoramic water lens*, specially constructed for making panoramic views on long curved plates.

Then came the celebrated triplet lens of Dallmeyer, which was a great improvement, as it then became possible to make pictures free from distortion (see fig. 251).

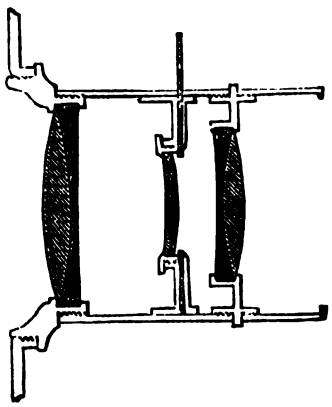


FIG. 251.—DALLMEYER'S TRIPLET.

It consists of a slightly meniscus achromatic, with its convex side turned towards the object. A little behind it is a nearly plane meniscus concave a chromatic, and a large lens of the same form as the front is placed at the ihe backend. If the central combination be removed, the focal length of the whole lens becomes reduced, and its angular aperture, previously $f/15$, is then sufficiently large for portrait work.

The need for lenses which should not give distortion was now apparent, and opticians and mathematicians strove hard to produce the required effect. Distortion may be shown in a simple manner by the appearance of a square grating after refraction, with a single lens having the diaphragm placed in front of it, and the field flat By fig. 252 it will be seen that when the refractory angle is greatest, viz., the farther from the axis, the pencils become more refracted towards it than they are as they approach it, the axis itself suffering no displacement. The pencils of rays it will be seen, converge towards the axis, and give what is known as "barrel-shape" distortion. The opposite, or pincushion distortion, is seen if the diaphragm be placed behind the lens, as in fig. 253; a divergence from the axis will take place, becoming more and more marked as the refracting angles become greater towards the edge of the lens.

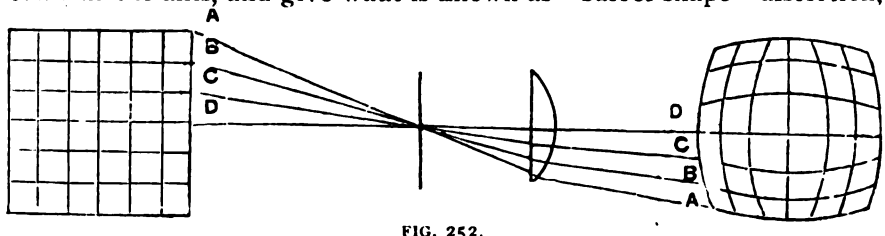


FIG. 252.

Of the two evils the lesser is chosen, and the diaphragm is usually placed in front of single lenses.

* See Fluid Lens.

In fig. 254, however, we see how this distortion can be remedied by two lenses having the diaphragm in the center, this being one of the principles upon which the rapid rectilinear and non-distorting lenses are made.

$$\frac{1}{v_2} = \frac{1}{1} - \frac{1}{u} + w_2 y_2 = \frac{1}{f^1} + \frac{1}{f^2} - \frac{1}{u} + (w_1 + w_2)\, y_2$$

and in general

$$\frac{1}{v^2} = \frac{1}{f^1} + \frac{1}{f^2} + \frac{1}{f_3} + \ldots + \frac{1}{f_n} - \frac{1}{u} + (w_1 + w_2 + \ldots wn) y^2$$

The object, then, for aplanatism is to make

$$|-| \qquad w = 0$$

Now this can always be done by assuming a definite ratio between the radii of one lens, and find ing the ratio between the radii of the second that shall destroy the first aberration.

Now, if we call r_1 s_1 the radii of the first lens, and r_2 s_2 the radii of the second lens, and take a form of aplanatic combinations such as the rapid rectilinear, in which both front and back combinations are identical with cemented and identical contracts, here s_1 r_2 are identical except in sign, and if the glasses chosen are suited, there is only one form for the best correction for spherical aberration. The ratio of the powers is constant, and, therefore, by a proper substitution in the above equations this construction becomes a simple matter. The question evolves itself into a simple quadratic, one root of which is imaginary. If both be imaginary, the glasses are unsuitabel for the purpose. In all doublets, the diaphragm being placed between the two combinations, the distortion of one is cured by the other.*

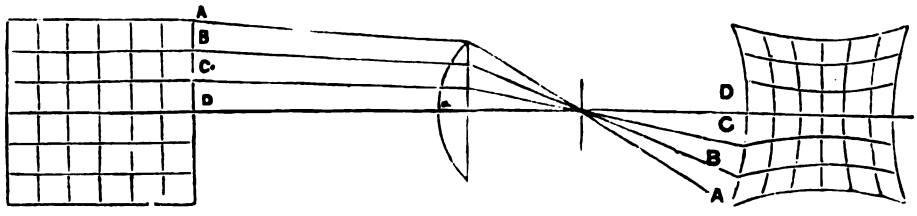


FIG. 253.

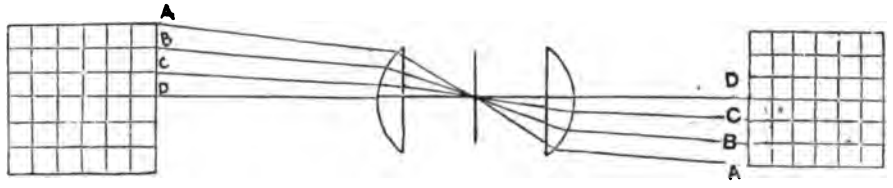


FIG. 254.

In the same year (1860) Harrison patented his globe lens (see **Globe Lens**), which had a very wide angle, but gave a flare owing to its globular form. It is also guilty of spherical aberration. Among the many non-distorting lenses that were introduced about this time must be mentioned Ross's doublet lens, or "actinic doublets," as they are called. Fig. 255 shows the manner in which the lenses are fixed. It is composed of two achromatized meniscuses, each of which can be separately used as a single lens. This was a great improvement upon the globe lens, as it is almost entirely free from spherical aberration and distortion. These lenses were manufactured in three series, *i. e.*, rapid, medium, and wide angle.

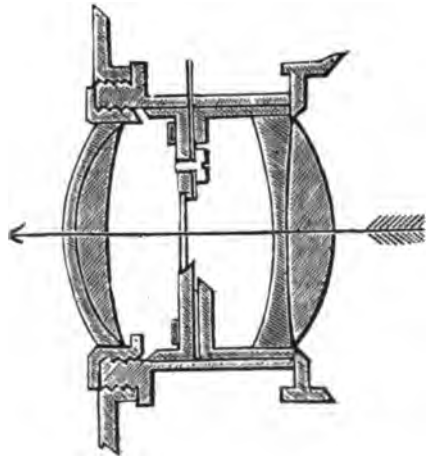


FIG. 255.—ROSS'S DOUBLET.

In the year 1864, Dallmeyer made a considerable modification in his single landscape lens introduced four years previous. A sketch of this modified arrangement is shown in Fig. 256.

In the following year (1865), Steinheil introduced his periscopic lens. This was a non-achromatized symmetrical doublet, the arrangement of which is shown in Fig. 257. The introduction of this lens, however, can hardly be considered a step forward, as neither lens was corrected for chromatic aberration, and consequently it was necessary to shift the camera to the chemical focus after focussing on the ground glass. The distance towards the lens that the focal plane is required to be moved is always the same fraction of the focal length, *i. e.*, $\frac{8.75}{1000}$. The inventor stated that focussing was unnecessary for the reason that near and distant objects were equally

* Dallmeyer.

clear, and consequently the slide holder could be adjusted permanently. This statement, however, is rather misleading. The lens included an angle of 90 deg., and was considered an advantage over the globe lens, that its diameter was only about one quarter for the same field.

Busch, of Ruthenow, also introduced a lens which he termed the pantoscope, shown in Fig. 258.

This lens is a cross between the globe lens and the peroscope. It is not aplanatic, and only works with a very small aperture, *f*/30 or *f*/40.

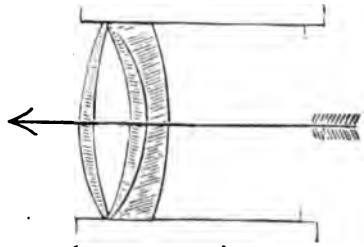


FIG. 256.—DALLMEYER'S LANDSCAPE.

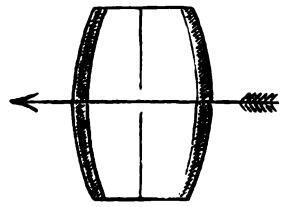


FIG. 257.—STEINHEIL'S PERISCOPE.

Passing on we arrive at the year 1866, a very important one in the history of photographic lenses, for in this year Dallmeyer introduced his rapid rectilinear and Steinheil his aplanatic lenses. Both these lenses appeared almost simultaneously, Dallmeyer's lens being preceded only by a few weeks by his wide-angle rectilinear doublet depicted in Fig. 259. This lens worked at *f*/13 to *f*/17, and has its back combination smaller than the front. By this means its reflecting power is diminished, and any tendency to flare reduced.

The aplanat of Steinheil is shown in Fig. 260. The similarity of the two lenses is at once seen. Steinheil, however, constructed his of two kinds of flint glass, a light and dense kind. Both lenses were achromatic.

These lenses of Dallmeyer and Steinheil are now very extensively manufactured, and sold under a variety of fancy names; used with a small diaphragm they include an angle of considerable extent.

Steinheil also constructed a landscape aplanat, Fig. 261. The working aperture of this lens was *f*/12 to *f*/15, and the angle of view above 95°. The wide angle aplanat, Fig. 262, is specially suitable for copying, as it gives perfect flatness of field of picture, and sharpness of definition, having at the same time a considerable field. The Steinheil extreme wide angle lens (Fig. 263, gives) an angle of about 100 degrees, having a proportionately short focus. They are suitable for interiors and architecture when compelled to photograph at short distance.

In this same year Dallmeyer also obtained a patent for a modification of the Petzval portrait lens (Fig. 264). In this the flint glass lens of the back combination was placed behind instead of in front of the crown glass. Another point about this lens was that the back flint glass lens could be moved very slightly backwards and cause the production of a definite and calculable amount of spherical aberration. This was termed "diffusion of focus," and much softer portraits are said to have been the result. This is now understood as naturalistic focussing.

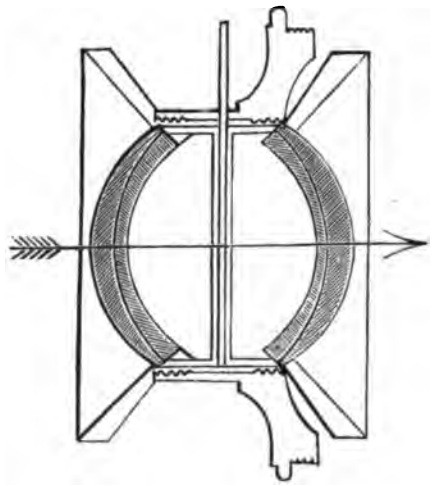


FIG. 258.—BUSCH'S PANTOSCOPE.

The next important introductions were the lenses of Steinheil, who departed very considerably from the rules laid down by opticians for the construction of lenses. These he called "anti-planatic lenses." In the accompanying figure (No. 265) we have the anti-planatic lens for landscapes and groups; and in Fig. 266, we have the design for portraits and in Fig. 267 an all round lens suitable for portraits, groups, architecture, landscape, and instantaneous work.

In both these lenses the anterior combination possesses a shorter focal length than the whole lens, and the back combination is diverging. Both combinations give considerable spherical aberration, but are so arranged that the extent of each is equal in an opposite direction, so that two combined neutralize each other and produce a corrected whole. The working aperture of the view lens is *f*/6 and of the portrait lens *f*/3.

In the year 1888 Dallmeyer introduced a rectilinear or non-distorting lens, working with a very large aperture and free from distortion and astigmatism, and giving a very flat field.

Having thus endeavored to give a description of the various forms of lenses, we will next consider the points in choosing lenses for various classes of work.

The lens is undoubtedly the most important instrument in the hands of the photographer, and upon its careful choice rests his

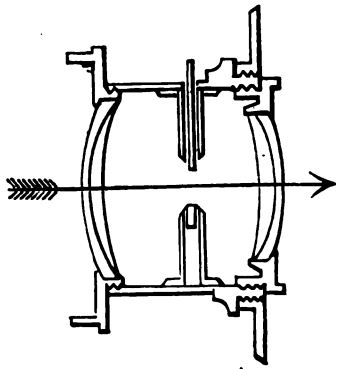


FIG. 259.—DALLMEYER'S RAPID RECTILINEAR.

future success. So much commercial deception now exists, that the only reliable method of ensuring the procural of first class lenses is to obtain them from well-known makers. No one lens can be perfectly adapted for all purposes; it therefore becomes necessary for the photographer, if he is desirous of attempting various kinds of work, to have a varied selection of lenses. For simplication we will divide lenses into two principal classes, *i. e.*, view lenses and portrait lenses.

In choosing a view lens the first considerations are:—

1st. The size of the picture required.

2nd. The angle of view or amount of subject to be included.

3rd. The kind of picture, viz., whether landscape, architectural, or both. With regard to the first point—the size of the image. The relation between the size of an object and that of its image depends simply upon their respective distances from the optical center of the lens. If, for example, the object is ten feet distant, and its image one foot, the image is one-tenth the size of its object. And as the distance of an image depends upon both the distance of the object and the focus of the lens employed, it is evident that with an object at fixed distance the size of its image is proportional to the focus of the lens.

The second point, the angle of the view to be included in the picture, depends upon the relation of its size to the focal length of the lens, that is to say, the shorter the focus the larger will be the angle, and *vice versa*. Referring to the proper angle for new lenses, Dallmeyer, in his "Choice and Use of Photographic Lenses," says that "the human eye itself is a miniature photographic camera, inasmuch as the several rays proceeding from objects, upon entering the eye, are refracted by its lens, and thence proceed to form a perfect image or picture on the smooth screen of nerve called the *retina*; and that it is by this picture that the mind is enabled to judge of the dimensions, brightness, color, &c., of external objects. The angular extent of the picture formed upon the retina does not exceed 60 deg. without some movement of the eye or head. Hence for a photograph to convey to the mind a correct idea of the objects represented, it should, when viewed at the normal distance of from 12 to 15 inches, excite the same impressions. Now the distance at which a picture is generally viewed will be found to be about equal to its base, or longest side; or, in other words, the angle it subtends for vision will be from 50 to 60 degs. This angle, therefore, should not be exceeded, for if more is included in the picture, the perspective will appear exaggerated, *i. e.*, objects in the foreground will be too large, and the distance becomes dwarfed.

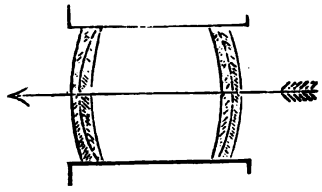


FIG. 260.—STEINHEIL APLANAT.

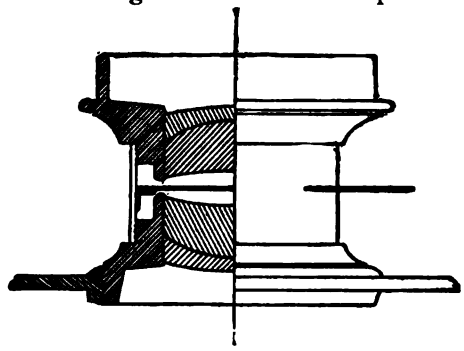


FIG. 261.—STEINHEIL LANDSCAPE APLANAT.

"To render it obvious that distortion of this nature is really no fault of the lens, such pictures need only be viewed at a distance equal to the focus of the lens with which they are taken, when all apparent distortion at once vanishes. This rule holds good in all cases, *i. e.*, every picture should be viewed at a distance equal to the focal length of the lens with which it is taken. Thus a 12 x 10 picture taken with a 7-inch focus wide-angle rectilinear lens should be looked at not at 12 or 15 inches, but at 7 inches distance from the eye."

From this it will be seen that wide-angle lenses can only be used in landscape photography when absolute truth of delineation is to be disregarded for the sake of beauty. In photographing architectural subjects in confined situations, a wide-angle lens is often an absolute necessity, but it should only be used in such cases.

The best form of landscape lens is undoubtedly the "single combination," for the reason that this lens possesses only two reflecting surfaces; the most brilliant images are the result, and great rapidity of exposure is therefore possible.

The only objection to the single lens is its distortion, which only becomes apparent, however, when photographing objects containing straight lines, such as in buildings, etc., the same becoming slightly barrel shaped. To avoid this as much as possible, the building should be placed as near to the center of the picture as possible. It should be noted that in the various kinds of single combination new lenses now manufactured, other conditions being equal, the smaller its diameter the better the lens.

With regard to the focal length this should not be greater than the base line of the picture, that is to say, for a 10 x 12 in. plate a 12 in. focus lens, or a little longer, will be found most suitable.

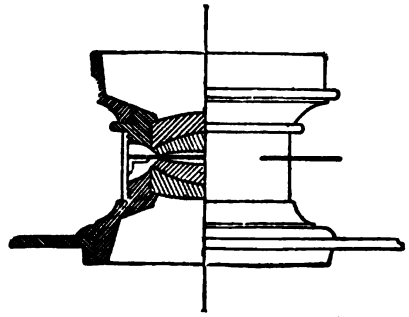


FIG. 262.—STEINHEIL WIDE-ANGLE APLANAT.

For architectural subjects it is, of course, necessary that a rectilinear lens be chosen, preferably one with a moderate angle. The rapid rectilinear is the most popular lens, owing to its freedom from distortion, and to its property of working with a larger aperture than any other kind of double lens. For photographing objects in confined situations the wide-angle rectilinear will be necessary, but as already stated, should only be used when circumstances compel it.

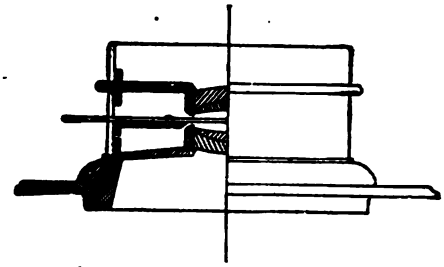


FIG. 263.—STEINHEIL EXTREME WIDE-ANGLE APLANAT.

In the selection of portrait lenses other considerations have to be made, the principal being the length of the studio, and consequently the distance from the lens that the subject can be placed. This is usually considered to be between 12 and 24 feet. If less than 12 feet the image will generally be found wanting in definition and correct perspective, for the reason that the lens will possess too short a focus. Carte-de-visite portraits are generally taken with lenses of such focal length as to require a distance of between 14 to 20 feet. For this distance between the lens and the sitter, the equivalent focus should be about double the base-line of the plate—for instance, for a quarter or carte-de-visite, $3\frac{1}{4} \times 4\frac{1}{4}$, the focal length would be $4\frac{1}{4} \times 2 = 8\frac{1}{2}$ inches.

An essential point in portrait lenses is rapidly of action, as in photographing babies or other restless or nervous sitters only a very brief exposure is permissable. The rapidity of the lens is governed by the diameter of its working aperture and its focal length. Quick-acting portrait lenses can only be used, however, with considerable sacrifice of flatness of field and depth of definition. An example of this may be seen if we have two lenses of equal focal length bot properly corrected for spherical aberration. Let one have a diameter of two inches and the other of four inches; the latter will be four times more rapid than the former, but will possess only half the depth of focus. These rapid portrait lenses will only be found to give good results if used for small-sized images; for large pictures slower acting lenses giving greater depth of focus are required.

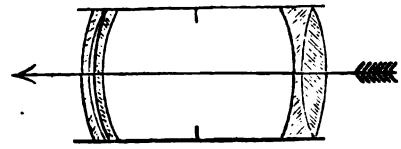


FIG. 264.—DALLMEYER PETZVAL PORTRAIT LENS.

If for an amateur requiring a good all-round lens with which he can make landscapes, architecture groups, portraits, instantaneous views, etc., the double combination rapid rectilinear is undoubtedly the most suitable—it will, of course, be understood, however, that the different classes of work can never be so well executed as with separate lenses suitably and specially constructed for each kind of work.

The rapid rectilinear will also be found very useful for copying purposes, and also for enlarging and reducing.

The various aberrations that lenses are guilty of have already been explained under **Aberration.** The methods of testing for these defects have already been described. If, however, a lens be purchased from a good maker, very little fear need be entertained as to its suffering from any serious defect.

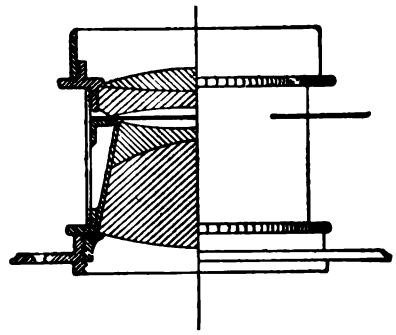


FIG. 265.—STEINHEIL ANTIPLANATIC FOR GROUPS.

LENS, CEMENT FOR.—See **Cement.**

LENS SCREEN OR HOOD—An arrangement fitted on to the front of the lens to screen off asmuch as possible of the side light and prevent all rays, save those emanating from the object to be photographed, from striking the lens or the inner parts of the mount. Nearly every lens is fitted with a hood in front which serves as a light screen. If required to be larger, however, an extemporized conical tube of blackened cardboard can be readily constructed. Another form of hood, termed a sky shade, was formerly used, but is rarely seen nowadays.

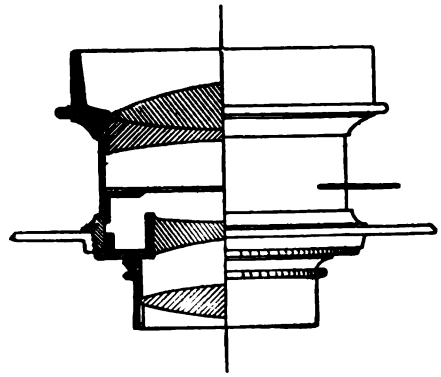


FIG. 266.—STEINHEIL ANTIPLANATIC PORTRAIT

LENS TUBE,—The metallic tube supporting the lens. It is usually of brass although aluminum has been used on account of its lightness. It is, however, liable to deteriorate.

LENTICULAR.—Having the form of a double convex lens.

LEPTOGRAPHIC PAPER.—A kind of colodio-chloride paper, introduced on the Continent about the year 1866.

LEVEL.—An instrument for indicating a horizontal

line or the horizontal position of a surface. The simplest form is the spirit level as used by carpenters and others. In this is a glass tube, hermetically sealed at both ends, containing spirits of wine, which does not freeze, and a small air bubble. When the air bubble is in the center of the tube the instrument is in a horizontal position. Instead of a tube a small round disc is sometimes used. When the bubble is in the center it shows a level position every way, thus obviating the necessity of shifting the instrument in different directions. A small spirit level of this description is often attached to the camera to facilitate its erection in a horizontal attitude. The form we illustrate (Fig. 270) is a double level that can be screwed on to the camera, or rather to the swing back, if one is used.

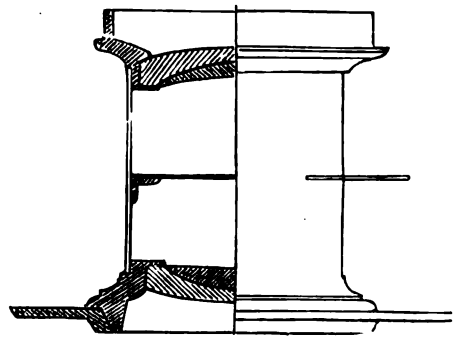


FIG. 267.— STEINHEIL ANTIPLANATIC LENS. SERIES III.

LEVELLING STAND.—An instrument constructed to support a plate of glass, slate, or other substantial material in a horizonal position, so that liquids poured on it can be made to spread evenly over without overflowing. It is usually constructed in the form of a tripod, with three adjusting screws, with which the operation of leveling is accomplished.

LICHT-DRUCK.—A photo-mechanical process, largely worked in Germany, and known in this country as albertype, collotype, etc.

LIFTER.—See **Plate Lifter.**

LIGHT.—Light has been defined as the mechanical effect produced upon the extension of the optic nerve, which forms the sensitive surface of the retina. We do not know what it is, or why it makes objects visible and appear of different colors, or why it produces chemical changes in various substances. Although the causes remain a mystery we know the effects, and a study of these is of the highest importance to the photographer. In the limited space at our disposal it will only be possible to deal with the most important points, but the study of reliable works on the subject is strongly recommended.

FIG. 268.—VOIGHTLANDER'S COLLINEAR LENS.

Two leading hypotheses regarding the nature of light have been put forward. The first was known as the emission or corpuscular theory. This theory of the propagation of light, although supported by the names of Newton, Laplace, and Bist, has been abandoned, and the second or undulating theory has taken its place. The latter assumes the existence of an extremely subtle elastic medium, filling all the space of the universe, termed the "luminiferous ether," the undulations of which constitute light, and, when they impinge upon the retina, produce vision. These undulations will be more clearly understood by the following experiment:—In a still pond throw a stone; waves are produced in circles or rings, which proceed from the spot where the stone struck the water, widen out, and as they extend become gradually less and less, until they finally disappear. If several little stones be thrown in at different parts of the pond, each will have its own system of undulating waves. These, although intersecting each other in the most complicated manner possible, will not be found to interfere with each other at all, and although a confused mass of circles appears, yet on close examination every circle will be found to widen out regularly from its own center, without the slightest interference from the countless other circles. Another feature of this remarkable undulating motion is that the water itself appears to proceed outwards from the central point. But this, however, does not happen, as can be proved by throwing a few pieces of paper on to the water, when they will dance up and down upon the little waves without moving from the spot. Correctly speaking, the paper at any point moves in an elliptic orbit, each particle moves in a similar orbit to its predecessor, but a little later, this movement being communicated further and further, and thus what we term the "wave" is propagated.

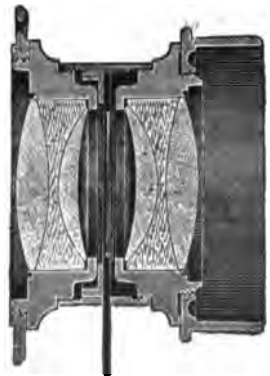


FIG. 269.—GOERZ DOUBLE ANASTIGMAT.

In precisely the same manner, light spreads in undulations from a luminous body through the ether. The undulating movement is termed a ray of light, and we perceive it as soon as it reaches our eye. Recent microscopical researches have shown that the

retina of the eye is studied with very fine rods, and, although not yet clearly understood, it is supposed that this is the true method of vision. The wave of light strikes these, rods, and the optical image, or the retina is transformed to consciousness in the brain.*

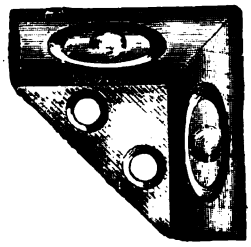


FIG. 270.—CAMERA LEVEL.

Several methods of calculating the velocity with which light is transmitted are known; this is stated to be about 186,000 miles per second. It will be seen, therefore, that the time occupied in traversing terrestrial distances is too small to be appreciable, unless by specially constructed apparatus. It is interesting to note that the nearest fixed star being probably about 200,000 times further away from this earth than the sun, it becomes visible to us now by the light which left it rather more than three years ago. Taking into consideration the high velocity of light, some slight idea may be gathered from this of the vastness of the universe.

In any homogeneous medium light moves in straight lines until obstructed or deviated from its course by some body. All bodies are either transparent, translucent, or opaque. Transparent or diaphanous bodies are those through which light passes easily; translucent bodies are those through which light passes less easily, being partially reflected; and opaque bodies are those through which light cannot pass at all. When light falls upon the surface of a body, part of it is reflected. If the surface of the body be smooth and polished, the eye, if placed to receive the reflected rays, will generally observe an image of the illuminant, and the body may be termed a mirror. If, however, the same be not smooth the light falling upon it is scattered in all directions, so that the surface itself becomes visible; while a portion of the light is reflected, a part enters to a certain depths, or, in other words, is absorbed. A ray of white light is, as we know, composed of all the colors of the spectrum. Certain bodies have the properties of absorbing some of these colors and reflecting others, and so we get the phenomena of color. For instance, a body which absorbs all the primary colors but blue will appear blue, one that absorbs all the colors and reflects none will appear black, and one that absorbs none will appear white.

If light falls almost vertically on to a glass surface very little of it is reflected, but as the angle of incident is increased the greater becomes the proportion of light reflected. The law of reflection was known to Archimedes; it is that the incident and reflected rays make equal angles, with a perpendicular to the surface, and lie in the same plane with it; thus, the angle of incidence is equal to the angle of reflection. (See **Reflection.**)

When a ray of light passes from one transparent medium to another, unless perpendicular to the surfaces of both, it is bent aside or refracted at that point where it enters the new medium, This refraction of a ray of light, when passing from one medium, such as air, into another. such as water, is subject to a particular law. This law of refraction, which was known as far back as the 17th century, is this: Whatever be the obliquity of a ray passing from one medium to another, the sines of the angles made by the incident and refracted rays, with the perpendicular to the refracting surface, are in constant ratio. The power of refraction is termed the index of refraction, and differs for every different substance, but remains always the same for one particular substance. Refraction only occurs at the surface of transparent media. (See **Refraction.**) The mathematical applications of reflection and refraction are termed optics. A ray of light which is refracted through a medium, having parallel surfaces, will have the same direction on leaving as on entering, and if traversing two media having parallel surfaces, but differing in their refractive indices, it will emerge in a direction parallel to the incident ray. Newton discovered that red light is not refracted so much as blue light in passing from one medium to another. If a ray of light be refracted by means of a prism, it is separated into a number of different colored rays; these rays be thrown upon a screen and will produce a band of colors termed the spectrum. These colored rays may be passed through another prism, and will combine to form a ray of white light again.

Young showed† that two rays of light may destroy each other's effects and produce darkness. He applied this discovery to the explanation of many natural phenomena, such as the colors in mother-of-pearl on soap bubbles, etc. When a ray of light enters Iceland spar it is divided into two rays, which travel in different directions, and possess peculiar properties not exhibited by ordinary rays of light, and are said to be polarized. These polarized rays cannot be made to interfere or destroy each other, but either may be divided into two interfering rays.

Newton, in his experiments with solar light, discovered that the blue and green rays of the spectrum very slightly affect the thermometer, the yellow rays somewhat more, while the extreme red rays possess great heating properties, and, further, when the thermometer was passed beyond the red into the space where no luminous rays existed, the maximum heating effect was produced.

In photography we find that the red and yellow rays have the least amount of chemical effect upon sensitive substances, while the blue and violet rays exercise a rapid chemical action.

Before concluding these remarks on light, it will be well to photographers to consider the important part that light plays in the formation of the image. If the lens be removed from

* See Wright's "Light and Experimental Optics." † See Blackie's "Modern Cyclopædia."

the camera, and a piece of tin-foil placed over the opening, an experiment may be thus made. In the tin-foil make a small pin-hole. Immediately we have an inverted image on the ground glass screen of the object in front. Why? Because every straight ray proceeding from the object marks its color on the screen, and the sum of all these rays will therefore be an image of the object. Now, as these rays all cross each other at the hole, the image must necessarily be inverted. If a dozen pin-holes be made we get a dozen images, if a thousand, a thousand, and so on. The images will, of course, overlap each other more and more. Although the image produced by a pin-hole possesses perfect depth of definition and freedom from distortion, except that produced by the image being thrown on to a plain screen, yet photographically it is of little use, owing to the impossibility of obtaining sharpness of definition and sufficient brilliancy of illumination. The pin-hole is therefore replaced by a lens. The manner in which these are constructed and the choice will be found under **Lens.** (See also **Pin-hole Photography, Latent Image,** etc.)

LIGHT FOG.—See **Fog.**

LIGHTNING PHOTOGRAPHS. — Very successful photographs of lightning discharges have been made, showing the peculiar irregular course taken by the electric fluid, so unlike the con ventional zig-zag of the artist. No special apparatus is required, the photographs being made at night, the lightning exposing itself. The camera is merely placed in a suitable position, a plate inserted, and the lens uncapped to wait for a discharge. Notwithstanding the fact that scientists tell us that the lightning flash takes place in an incredibly small portion of a second, yet if the camera be moved during the visible duration of the flash a blurred image will be obtained.

FIG. 271.—PHOTOGRAPH OF LIGHTNING MADE AT BLUE HILL.

LIGHT-STRUCK.—A photograph plate is said to be light-struck or fogged when it has been altered by light from some extraneous source.

LIGNIN.—Synonymous with **Cellulose** (*q.v.*)

LIME.—See **Calcium Oxide.**

LIME, CHLORIDE (Formula doubtful, generally written CaCl.OCl; synonyms, *chlorinated lime, hydrochlorite of lime* and *bleaching powder*).—Prepared by passing chlorine gas into leaden or stone boxes, in which a quancity of moist slacked lime has been spread out on shelves. The. lime absorbs nearly half its weight of chlorine forming a white powder having a peculiar smell. The temperature during the process of manufacture is not al: lowed to get higher than 77 degrees F. This is ensured by acting on the fresh lime with chlorine diluted by air.

Its uses in photography are based upon the fact that the chlorine which it contains is in an easily available form, and may be liberated by any acid. It is also used in the preparation of zinc hypochlorite (used as a hypo-eliminator), and in toning. It decomposes by keeping, and old or moist samples should, therefore, be rejected. Insoluble in alcohol.

LIME LIGHT.—See **Oxyhydrogen Light.**

LIME WASH.—Many photographers coat the glass roof of the studio with a wash of lime which has for its purpose the softening of the light, and keeping the chamber cool. A wash for this purpose must be made to resist the action of rain, which can be simply done by mixing the lime with buttermilk instead of water. Whitewash made with size, and containing half a pint of boiled linseed oil to every ten gallons of water, is very good for the purpose.

Instead of lime, however, sulphate of baryta can be used. This is soaked in water for a

day, and then add one part of fresh glue size and one part of boiling water. One drachm of sodium bichromate is then added to each quart. When mixed to the consistency required, it may be applied to the roof with a large whitewash brush. The slight yellowish appearance at first observable will soon wash out.

LINE NEGATIVE.—A negative made behind a line screen and used in photo-engraving.

LINE SCREEN.—A screen having fine lines ruled upon it and used for photo-engraving work in the manufacture of half-tone blocks. These are supplied in almost any size and ruled up to 275 lines to the inch. The finest are made of plate-glass ruled with a diamond, the lines being filled in with black pigment. Two sheets of glass are cemented together, face to face, one having the lines one way and the other at right angles to them. See **Photo-Engraving.**

LINSEED OIL.—The oil obtained from the seeds of the flax, either by pressing when cold, or by heating to about 200 deg. Fahr. It is of a pale to dark yellow color, with a sp. gr. of about 0·93. It is largely used in the manufacture of printing inks, etc.

LIP OR MOUTH GLUE.—A convenient portable cement of considerable adhesiveness. Four ounces of the very best glue and one ounce of isinglass are soaked in water until quite soft. The water is then poured off, and one ounce of brown sugar added. The whole is melted, stirred well together, and allowed to evaporate until quite thick. It is then poured on to a flat bottom dish, preferably placed on ice, to prevent the glue sticking. When quite solid it is cut up into cakes. This glue only requires wetting with the tongue to be very useful for various purposes.

LIQUID GLUE.—See **Glue.**

LIQUID AMMONIA.—See **Ammonia.**

LITHARGE.—Protoxide of lead, PbO. A heavy, yellow powder, usually obtained by oxidation of the metal in a current of air.

Litharge is much used as a dryer in painting. Dark-red colored is called lithrage of gold, and the paler-colored variety, lithrage of silver.

Sutton, in his "Dictionary of Photography," says: "Water which has been filtered through lithrage increases the energy of the developer which is dissolved in it, but this should be used immediately, for it will not keep. There is also danger of its producing fog upon the plate."

LITHIUM (Symbol, Li; atomic weight, = 7).—A comparatively rare metal, chiefly obtained from the minerals *lepidolite* or *lithia mica*, which contains silicate of alumina and potassium and lithium florides, and from *petalite*, containing silicate of soda, lithia, and alumina. In a hot spring in the Clifford mines, in Cornwall, the water contains 26 grains of lithium chloride per gallon.

Lithium is the lightest solid body known, having a density of only 0.5936.

LITHIUM BROMIDE (Formula, LiBr; molecular weight, = 87).—Prepared by direct combination of lithium and bromine. It is very soluble in water and alcohol, and is sometimes used in the preparation of bromide emulsions.

LITHIUM CHLORIDE (Formula, LiCl; molecular weight, = 42.5).—Occurs in mineral springs. It may be prepared by dissolving lithium in hydrochloric acid. It is one of the most deliquescent substances known. Employed in collodio- and gelatine-chloride emulsions.

LITHIUM IODIDE (Formula, LiI; molecular weight, = 134).—Prepared by the combination of lithium and iodine. It is very soluble in both water and alcohol. Used in iodizing collodion.

LITHOGRAPHY.—See **Photo-Lithography.**

LITHOPHOTOGRAPHY.—Same as **Photo-Lithography.**

LITHO-PHOTOGRAVURE.—A photo-mechanical printing process, invented by Carl Eckstein, of The Hague. A lithographic stone is polished with oxalic acid and water, and then covered by means of a roller very evenly with a diluted asphaltum solution, prepared by boiling asphaltum five parts, white wax six parts, and stearine six parts, and adding to this two parts of soda solution, dissolving the whole after cooling in turpentine oil, filtering, and keeping in well-stoppered bottles. The thin film is then scratched with a diamond in very fine lines, ruled with a machine from about the $\frac{1}{80}$th of an inch apart, while the stone is evenly covered with them. An etching liquid is next poured over the stone, consisting of one-sixth part of pure nitric acid, six parts of alcohol of 36 deg., and 350 parts of distilled water. After half a minute the stone is rapidly washed, dried, oiled, the asphaltum washed off with turpentine, and then inked up; it is then ready for the transfer, which is then applied, and the subsequent operation resembles the ordinary processs of photo-lithography.

LITMUS OR LACMUS.—A blue vegetable coloring matter procured from the *Roccella tinctoria*, and other species of lichens, by fermentation with potash. It is obtained commercially in small cakes like chalk.

LITMUS PAPER.—Unsized paper steeped in tincture of litmus, and usually made up into small books. The blue color of the paper is changed to red by hydrochloric acid, and again becomes blue when mixed with an alkali. This property is very useful in chemical operations to test the alkalinity or acidity of a solution. According to Dr. Otto Foerster* commercial litmus of best quality is first extracted from ordinary alcohol in the cold, then digested with water, the solution filtered and evaporated. This is a combination of the processes proposed by Wartha and Mohr. The residue is again disolved in water, the solution filtered, and the filtrate precipitated with absolute alcohol mixed with a little glacial acetic acid. The precipitate is collected upon a filter and washed with alcohol. This causes a violet fluorescent coloring matter to remain in solution The remaining residue is once more dissolved in water, and the precipitation, filtration, and washing repeated. At this stage a red coloring matter, which has a violet tint in an alkaline liquid, remains in solution. After once again repeating this process only a small amount of the last named coloring matter remains in solution. The precipitate upon the filter is then dried, being repeatedly moistened during the drying with alcohol for the purpose of expelling the acetic acid. The precipitate is then dissolved in water, and the solution filtered. Finally, the coloring matter is precipitated with alcohol, rendered faintly alkaline with ammonia, then collected upon a filter, washed with pure alcohol, then dried.

LITRE.—A measure of volume according to the metric system. It is equivalent to 1 pint, 15 ounces, 1 drachm, and 43.69 minims.

LIVER OF SULPHUR.—See **Potassium Sulphide.**

LONG FOCUS CAMERA.—See **Camera.**

LUMINIFEROUS ETHER.—A hypothetical medium of extreme tenacity and elasticity supposed to be diffused throughout all space, as well as among the molecules of which solid bodies are composed, and to be the medium of transmission of light, heat, etc.

LUMINOUS PAINT.—A phosphorescent luminous paint, consisting of 100 parts by weight of carbonate and phosphate of calcium, (obtained by calcining sea shells†) mixed well together, 100 parts of pure lime and 25 parts of calcined sea salt, both measured by weight. Half the amount of the whole weight of sulphur is then incorporated by sublimation, and from five to eight per cent. of mono-sulphide of calcium or barium.

Balmain's luminous paint is a phosphorescent substance incorporated with a colorless varnish. The following directions for the manufacture of a luminous paint were recently given by a correspondent in *Photography:* "This substance is a calcium sulphide, and is easily prepared by cleaning thick oyster shells and then burning them until they are red-hot; when cool, roughly pound them and pick up all the black and dark pieces. When fairly clear, pound fine and place a layer of about half-inch thick in a suitably sized fireclay crucible, and then a layer of same thickness of flour of sulphur, then another of oyster shell ash, then sulphur, and so on until the crucible is filled to within one and a half inches of the top. Fill this space up with well-worked clay, and allow it to dry in a warm place; when dry, place the crucible and contents in the fire, and when a low blood red, endeavor to keep it at that for at least 60 minutes. Two hours would be better if the clay luting is done well. Allow it to cool slowly and then turn out the contents and pound to a powder. This will give you a very bright luminous paint. If wanted for use as a water-color, by the addition of gum senegal dissolved in water, or if for outside use, copal gum dissolved in turps and one-fifth the bulk of poppy-oil added. The poppy-oil is to prevent it cracking. If it is to be applied to iron, the iron *must* first be painted with an oxide of iron paint. or the luminous paint will soon lose its luminosity."

LUMINOUS PHOTOGRAPHS.—The late W. B. Woodbury used to make what he termed luminous photographs by exposing a piece of cardboard, coated over with a luminous paint, under a glass positive. The effect in the dark was very striking, a brilliant phosphorescent picture being the result.

Paper coated with luminous paint and exposed to light under a transparency will give a luminous picture in the dark. Of course the effect is not permanent.

LUNAR CAUSTIC.—See **Silver Nitrate.**

LUNAR CORNEA.—See **Horn Silver.**

* "Zeitschrift für anal Chem. 1889."

† Those of the genus *Tridacna* are most suitable.

MACHINERY, PHOTOGRAPHING.—To obtain a good photograph of a machine it is usually painted with a paint, that will dry with a dull surface. This is composed of the following:

Dry white lead	5 pounds
Lamp-black	2 to 5 ounces
Gold size	1 pint
Turpentine	1½ pints

The quantity of lamp-black added is varied to suit the machine or lighting. This paint is applied in the ordinary manner, and after photographing it may be removed with a rag soaked in turpentine. The object of its use is principally to avoid high reflections and consequent halation.

MACRO-PHOTOGRAPHY.—A term sometimes used to denote the enlargement of the negative.

MAGAZINE CAMERA.—A camera, usually of small size, arranged to hold a dozen or more plates, inserted in sheaths and manipulated from outside, the plates being brought into position for exposure, in succession, and thus obviating the necessity of carrying plate holders. The chief drawback to these cameras is the liability of a plate to stick fast, and thus prevent any more exposures being made until the camera has been put right in a dark-room. Fig. 272 shows the design of a magazine camera.

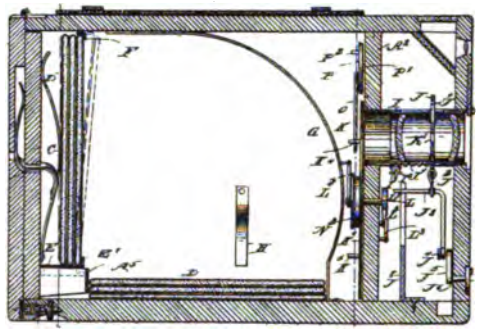


FIG. 272.—MAGAZINE CAMERA.

MAGDALA RED.—See **Naphthalene Red.**

MAGIC LANTERN.—See **Optical Lantern.**

MAGIC PHOTOGRAPHS.—A process for making these was first pointed out by Sir John Herschel. Prints on albumenized paper were first made and fixed without any toning. They are then washed thoroughly and immersed in a saturated solution of perchloride of mercury. The action of this solution is to bleach the image until it becomes of the same color as its paper support. It then becomes invisible, and is washed and dried. By simply laying a piece of dampened blotting paper, previously soaked in a saturated solution of hyposulphite of soda, the image will instantly re-appear, far brighter than before. It can then be washed, and a fairly permanent image obtained. These invisible images may also be developed by ammonia or by tobacco smoke. Some years ago a little novelty was brought out in Paris. It consisted of a cigar or cigarette tube (see Fig. 273), having a hollow chamber, through which the smoke passed. Small pieces of paper, on which were invisible images, manufactured as above, were then placed in the smoke chamber, and after smoking a cigar or cigarette, the picture, fully developed, was removed. Owing to the nature of many of these Parisian studies, however, many of them were better had they remained in the latent state.

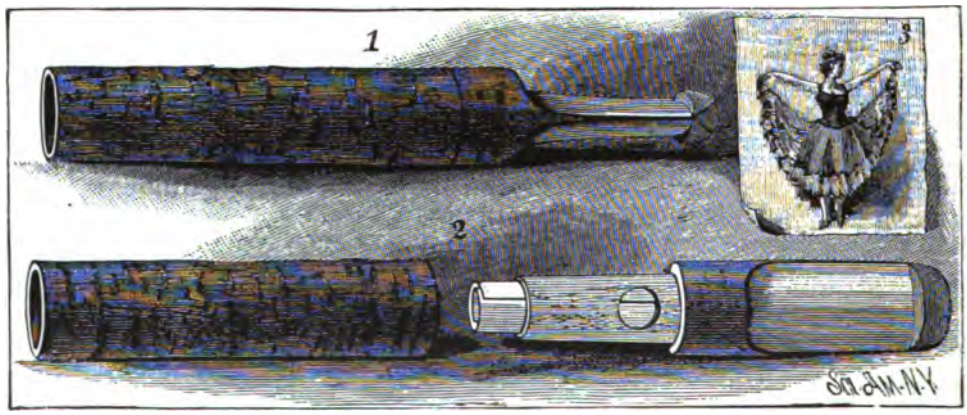
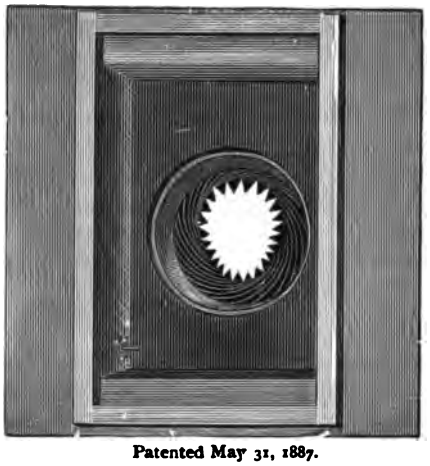


FIG. 273.—CIGARETTE TUBE FOR MAGIC PHOTOGRAPHS.

MAGIC VIGNETTE.—These are reversed vignettes, that is to say the margins round the portrait instead of being white as in the ordinary vignette are black. A method of making them was recently described by "Teinte" in *The Photogram*. This was as follows:

Two methods can be adopted. The first of these about to be detailed, though entailing, perhaps, in the first place a trifle more trouble, produces the best results. We require a black background, preferably of black velveteen, large enough for a head and shoulders. As the material is not usually obtainable of a width greater than twenty inches or so, there will have

to be a seam, and this must be very neatly done. The seamed velveteen is then stretched taut on a frame, which should preferably be covered first with calico, to prevent "sagging." Always, before use, dust the velveteen with a soft brush—say, a hat brush—to remove any adhering dust or fluff. Instead of velveteen, a good paper background can be used, only it must be seen that the surface is smooth and free from cracks or creases, and is *dead black*.



Patented May 31, 1887.

FIG. 274.—MAGIC VIGNETTER.

We require also a vignetting mask suitable to the subject, with a serrated edge. This has to be fixed inside the camera between the lens and plate.* The proper position can be found by trial; the further the card is away from the petal the softer and more gradual the vignetting. No special arrangement for holding this is required beyond what can be prepared by any one who can use his fingers. We take a piece of stout card, the outside of which will just fit into the folds of the camera's bellows, and by a little twisting it can be sprung in between the folds and will hold them. There is an opening in the center, square in shape, about quarter plate size. This acts as a frame to hold the vignetting mask which has the opening of proper size and shape. By using a frame as described the vignetter can be moved about up and down and from side to side, and when the correct position is found, fixed by drawing pins. The frame and vignetter should be blacked all over. For this purpose take some lampblack ground in turps, and mix with it a little gold size sufficient (found by trial) to prevent the lampblack from rubbing off when dry, but not enough to cause the paint to dry shiny.

A good distance to fix the vignetter is about one-third the extension of the camera when the object is in focus, measuring from the lens.

We adjust the camera so that the image of the figure falls in the correct position on the screen, and the vignette is made of such a size and shape as to give the amount required.

The shadow of the mask protects the edges of the plate surrounding the image, and in development we obtain a negative in which the image is vignetted into clear glass, and on printing from such the margins print dark. The printing of such a negative should be prolonged until the margins of the picture are quite lost, or they are apt to show after toning.

The sketch shows the arrangement of vignetter inside camera.

The other plan consists in making an ordinary negative, using preferably a dark background. From this is made a vignette in the ordinary manner. When this comes from the frame it is placed on a piece of clean glass—face up—and another piece of glass free from flaws placed over it. Now cut a piece of card to the size and shape of the vignetted portion of the print, and fix this with glue to a piece of cork. This piece of cork must vary in thickness with various pictures. Now place the cork on the glass so that the mask covers the picture and fix with glue to prevent slipping. Place the whole out in diffused light, and allow the darkening of the margins to go on until sufficiently deep. The print is then toned.

The height of the card from the print must be such that no abrupt line is produced between the first printing and the darkened margin, but that one will shade into the other without break.

MAGILP or **MEGILP.**—A gelatinous compound used by artists for thinning oil colors and for glazing delicate tints on finished paintings. It is made by mixing linseed oil and mastic varnish together, the proportions varying according to the work. It is thinned with turpentine.

MAGNESIC CHLORIDE (Formula, $MgCl_2 6H_2O$; molecular weight = 253).—Occurs in sea water, or may be prepared by dissolving magnesia in hydrochloric acid. It is a white, crystalline powder, with a sharp, bitter taste, soluble both in alcohol and water. It is sometimes employed in the manufacture of gelatino-chloride emulsions. Liesegang discovered that it could be used as a fixing agent. Its superiority to hypo has not, however, been demonstrated.

MAGNESIC SULPHATE (Formula, $MgSO_4 7H_2O$; molecular weight = 246; synonym. *Epsom salts*).—Found in sea water and in many natural springs. It is, however, usually manufactured in large quantities by dissolving magnesian limestone in dilute sulphuric acid, and filtering from the insoluble calcio-sulphate. It is soluble in water, and has a nauseous, bitter taste. It has been recommended as a preventive of frilling in the gelatine process.

MAGNESIUM (Symbol, Mg; atomic weight = 24).—The metallic base of magnesia. It occurs in large quantities as dolomite or mountain limestone. It may be obtained by decomposing magnesium chloride and potassium. The metal is of a white color, like silver, it is very malleable and fuses at a red heat. It is sold commonly in the form of wire ribbon and powder. It

*A vignetter for the purpose, as shown in Fig. 274, has been placed on the market.

is used as an artificial light and has also been recommended for precipitating the silver from old fixing baths.

MAGNESIUM FLASHLIGHT.—A flashlight produced by suddenly igniting magnesium powder. Under **Flashlight** is described an instrument for producing flashes.

MAGNESIUM LIGHT.—An artificial light produced by burning magnesium wire or ribbon on a suitably constructed apparatus. The magnesium light is very rich in chemical rays, and is for this reason often employed in photography, in making exposures at night or in dark places

MAGNIFIER.—A convex piece of glass or a lens having the property of magnifying. A magnifying glass will often be found useful in obtaining sharp definition of the image upon the focusing screen. Mounted for this purpose it is usually termed a focusser (*q.v.*).

MALIC ACID (Formula, $C_2H_3.OH(CO_2H_2)$; synonym, *hydroxysuccinic acid*).—This was discovered by Scheele about the year 1785. It is very widely diffused throughout the whole vegetable kingdom, and may be found in abundance in nearly all garden fruit and plants. It is chiefly extracted from the juice of the unripe berries of the mountain ash. Malic acid appears commercially as colorless, shining needles; these are odorless, with a sour taste, and soluble in alcohol. It yields neutral and acid salts. It is sometimes used in photography as a preservative of silver nitrate. Sensitive albumenized paper, floated on a weak solution of malic acid, will keep for a considerable length of time.

MANGANESE BINOXIDE (Formula, MnO_2; molecular weight, 86; synonyms, *manganic dioxide, black oxide of manganese*).—A neutral substance occurring in nature as the ore of manganese, a black crystalline powder. It is made up into cakes, and used for the production of oxygen for the limelight.

MANGANESE PROCESS.—This process consists in floating gelatinized paper on a solution of manganic lactate. When dry the sensitive surface has a brownish color. The action of the light upon the paper placed behind the negative is to bleach it and form a faint positive image. It is less sensitive, however, than albumenized paper. Development can be effected with aniline sulphate, acidified with hydrochloric acid, orthotolindine sulphate, and paramidophenol sulphate, blue, green, and brown pictures being obtainable. A large number of other organic compounds can also be used for development. The stronger the solution the more vigorous the images, and the addition of ammonia reddens the tone.*

MARBLE, PHOTOGRAPHING ON.—A pretty effect is obtained by printing a photograph on marble, which can be done in the following way: An unpolished plate of marble must be coated with a solution of benzine, 500 parts; spirits of turpentine, 50 parts; asphaltum, 50 parts, and pure wax, 5 parts. When this is dry the plate is exposed under a negative, which will take in sunshine about twenty minutes. Develop with spirits of turpentine or benzine and wash in plenty of water. The next step is to cover the plate where it is intended to be left white with an alcoholic solution of shellac, and immerse the same in any dye which is soluble in water. After awhile, when enough of the coloring matter has entered the pores of the marble, it is taken out and polished.

MARBLED PRINTS.—A defect in printing, caused by the use of a too weak sensitizing solution, or to the paper having been floated for too short a period. It may also arise from imperfect albumenizing. The prints appear peculiar, unevenly marked, somewhat resembling the appearance of marble.

MARINE GLUE.—A useful composition for mending various substances, and for cementing pieces of glass together to make glass baths. It can be made as follows:—Digest from 2 to 4 parts of indiarubber, cut up into small pieces, into 40 parts of benzole, and cause them to dissolve by the application of heat and occasional agitation. The solution thus formed should have the consistency of thick cream. Next add 80 parts of powdered shellac, and melt the mixture on a slow fire, constantly stirring. When melted and thoroughly mixed it is poured out on to metal plates to allow it to cool in sheets. When required for use it is melted at about 250 deg. in an iron pot, and with a brush it is applied to the surfaces to be joined. As soon as it has become hard it is moistened with benzole and the pieces pressed well into contact.

MARSH GAS.—A name given to light carburetted hydrogen (CH_4).

MASKING.—A device often adopted in printing from imperfect negatives. In many the sky prints too deeply. A mask cut to the outline of the sky is laid on the negative, the edge slightly raised from the surface. This will give a graduated sky. Parts of the negative that print too deeply may be improved by pasting small pieces of tissue paper to the reverse side of the negative. (See also **Printing**).

MASKS AND DISCS.—Pieces of opaque paper used in printing. Out of the paper various shaped openings are stamped. The piece thus cut out is called a disc, and the margin remaining

* From experiments by R. Child Bayley.

the mask. If the opaque mask be placed between the negative and the sensitive paper, the picture will naturally be of the same form as the opening from whence the disc was cut out, the remaining parts of the paper being white. Prints may be finished in this manner, and, with some subjects, have a very neat appearance. Or they may be further altered by laying the disc over the printed part and coloring the margin by exposure to the light, either to a light shade or to a deep black color.

MASTIC.—A resinous oxidation drawn from the *Pistacia lentiscus*. It contains about 90 per cent. of a resin, readily soluble in alcohol, used for the manufacture of varnishes. Large quantities come from the Levant in the shape of drops or tears of a yellowish-white color. East India mastic is of an inferior quality. It is insoluble in water, but soluble to the extent of about 90 per cent. in alcohol, ether, chloroform, oil of turpentine, and benzole. The residue is a viscid and difficultly soluble resin. It is used in the manufacture of several varnishes.

MAT.—A piece of paper or other material having a suitable aperture, and used as a frame to the image. For a suitable mat for lantern slides see **Boston Mat**.

MATT PAPER PRINTS.—Prints made upon a matt surface paper present a very artistc appearance.

The paper is first coated with

Water	20 ounces.
Simeon's gelatine	160 grains.
White sugar	60 grains.
Ammonium chloride	50 grains.

After the gelatine is well soaked it is dissolved in a warm water bath, and all the other ingredients, and about one drachm of barium sulphate added. Stir the solution well up, and add about 6 grains of chrome alum. The whole is then filtered through flannel or chamois leather, and poured into a large flat dish standing in warm water. Immerse the paper in the solution for about five minutes, and then hang up by clips to dry. Several sheets of paper may be immersed at the same time if kept from clinging to each other; air bubbles must also be avoided.

To sensitize, it is floated on the following bath for about a minute or a minute and a half:

Water	10 ounces.
Silver nitrate	500 grains.

Dissolve and add to five ounces of it strong liquid ammonia until the precipitate at first formed is dissolved. Then add the remaining silver solution and filter.

When sensitizing, the paper is hung up to dry in a warm, yellow lighted room. Any toning bath may be used, those giving black tones are most suitable. The prints must be well washed before and after both the toning and fixing operations.

Very pretty engraving-like effects may be produced by this process if the prints be made on large pieces of paper with a wide margin made by printing under a black mask.

MATT SURFACE.—A dead or dull surface unpolished by burnishing or by any other means. From an artistic point of view the matt surface presented by a platinotype is far superior to the brilliant image of a highly polished picture, although for some subjects the latter is method preferable. Gelatine prints, such as bromide or aristo, may be made to present a matt surface by squeegeeing when in a wet state to a piece of ground glass and removing when dry.

MATT VARNISH.—See **Varnish.**

MAXIMUM THERMOMETER.—A thermometer arrange to indicate the highest temperature attained during the day.

MEALINESS.—A defect sometimes observable in silver printing. The surface of the print presents a peculiar mottled appearance. This is generally due to the sensitizing bath being too weak.

MEASLES.—A defect in silver printing. If the prints be held up to the light, opaque and semi-opaque blotches will be observed. These are caused by imperfect fixation by the insoluble hyposulphite of silver. If the prints be preserved, these spots will shortly become yellow, due to the formation of silver sulphide. They then present much the same appearance as the human ailment from whence the name is taken.

MEASURER, VIEW.—An instrument devised by M. Vidal for measuring the length, breadth, and width of the image reflected on the sensitive plate without the aid of a focusing glass. An instrument similar to to that depicted in fig. 275.

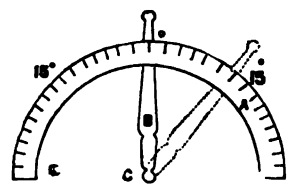


FIG. 275.

A is a brass semi-circle divided into degrees, B the alidade, and C the pivot on which the alidade is fixed. The angle of the lens is first noted; supposing this to be 30 deg., the alidade or hand is moved to the right until it lies upon the 15 deg. of the semi-circle. Now, in looking along it, the operator can easily see what he takes in on the right side of

the camera. The alidade is then moved to the left until it lies on the 15 deg. What will be reproduced upon the sensitized plate can thus be easily seen. In order to find out whether or not too much sky is included, another similar instrument is placed on the side of the camera. (See also **View Finder.**)

MEASURES.—See **Weights and Measures.**

MEASURING GLASSES.—A glass vessel used for measuring liquids. In purchasing these it is important to assure oneself of the legibility of the figures with which the glasses are graduated.

In measuring liquids in graduated glasses mistakes may often occur, owing to the fact that the surface of the liquid is not a level plane but has a meniscus curvature, the liquid being drawn up the sides of the glass by capillary attraction. Another point to be observed is that the glass be held perfectly upright; a slight error in this respect will often make a very great difference in the final results.

Narrow deep cylindrical vessels give more accurate measurement than conical ones, and are much to be preferred when accuracy is desirable.

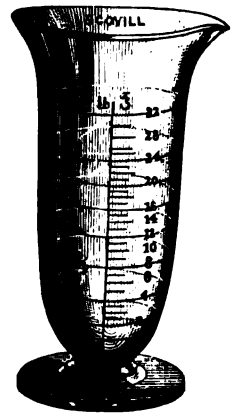


FIG. 276
MEASURING GLASS.

MEGASCOPE.—An optical instrument for exhibiting bodies on a large scale.

MEGATYPE.—A process of enlarging photographs.

MEGILP.—See **Magilp.**

MEISENBACH PROCESS.—A process of photo-engraving. It is described as follows:—A positive transparency is made of the object, and a transparent plate is hatched or stippled in parallel lines. The two plates are then joined face to face, and a negative made in the usual manner. The negative thus obtained has the appearance of being broken up into minute dots. In order to cross-hatch and break the lines of the shading the stippled plate may be shifted once or twice during the production of the negative. From the negative thus obtained the image may be transferred to zinc, or a lithographic transfer may bemade in the usual manner, and the plate subsequently treated with acid to form a block in relief. (See **Photo-Engraving**).

Considerable importance is attached to the shifting of the stippled plate, this being specially sought to be protected by the patent.

MELANOTYPE or **MELAINOTYPE.**—A positive process of American origin, and the name of which is derived from the black color of the material which supports the picture. Thin sheets of iron are coated on both sides, with a black Japan varnish. One side is very smooth and highly polished. When collodionized, sensitized, and in every way treated as in the collodion positive process on glass these plates give very fair results, and possess the advantage over glass plates, that they are not so easily fragile. This process is almost synonymous with Ferrotype.

MELTING POINT.—See **Fusion.**

MENISCUS.—A lens convex on one side and concave on the other. The concave side has a curve of greater radius than the convex side, the lens is consequently thicker in the center than anywhere else. (See **Lens.**)

MENSTRUUM.—Any fluid or substance which dissolves a solid—a solvent.

MERCURIC CHLORIDE.—(Formula, $HgCl_2$; molecular weight, 271; synonyms, *perchloride of mercury*, *bichloride of mercury*, *sublimate*, *corrosive sublimate*, *muriate of quicksilver*.)—A white heavy compound, which can be prepared by heating mercury in an excess of chlorine. Commercially, it is usually manufactured by sublimation, from a mixture of mercuric sulphate and common salt. It takes the form of heavy, colorless, prismatic crystals, sometimes sold in a powdered state. Solubility about 1 in 16 parts of cold water, and about 3 of hot water. It is also soluble in alcohol and ether. It is more soluble in the presence of ammonium chloride, as the latter converts it into the more soluble double chloride of mercury and ammonium. It melts at 510 deg. F. When dissolved in water, it is liable to become decomposed, but the addition of a soluble chloride will effectually prevent this. Barcker recommended the addition of hydrochloric acid.

Mercuric chloride is a powerful poison. It is readily absorbed by the skin, and being very injurious to it, contact should be avoided as much as possible. (See **Poisons.**)

It is used in photography chiefly for intensification (*q.v.*)

MERCUROUS CHLORIDE (Formula, HgC; molecular weight, 235·5; synonyms, *subchloride of mercury*, *calomel*, *chloride of mercury*).—A yellowish-white powder, insoluble in water,

alcohol, and ether. The bleached image in mercurial intensification is composed of chloride of silver and mercurous chloride. On the application of ammonia it is immediately changed to black mercurous ammonium chloride, thus—

$$_2HgCl + _2NH_4OH = NH_2HG_2Cl + NH_4Cl + _2H_2O.$$

If sodium sulphite be used, however, the mercurous chloride is reduced to black metallic mercury.

$$_2HgCl + Na_2SO + H_2O = Hg. + Na_2SO_4 + _2HC.$$

MERCURY (Symbol, Hg; atomic weight, 200).—A silvery white metallic liquid, which solidifies at 39 deg. F. It is found native in various parts, but is chiefly obtained by roasting the ore cinnabar (an impure sulphide), which is obtained from China, Spain, America, and other countries. It has a specific gravity of 13·5.

Mercury was formerly used in the Daguerreotype process to develop the image. It is due to the accidental discovery of the action of mercury on the exposed plate that Daguerre first succeeded in obtaining light images.

MERCURY PERCHLORIDE.—See **Mercuric Chloride.**

MERCURY SUB-CHLORIDE.—See **Mercurous Chloride.**

META-BISULPHITE OF POTASH.—See **Potassium Meta-Bisulphite.**

METAGELATINE.—Gelatine, if heated and then allowed to cool, and this process repeated teveral times, will cease to gelatinize on cooling, and will remain in a fluid state. It is then termed metagelatine, otherwise known as liquid glue. It was formerly used as a preservative in the collodion process. It dries to a hard transparent film upon collodion. If used as a preservasive a little gold syrup must be added. It is also used in the enamel process of half-tone engraving.

METALLIC SPOTS.—Small black spots which make their appearance in albumenized and other papers when sensitized with silver. These spots, due to small pieces of metal embedded in the paper, are usually quite imperceptible until the silver solution is applied, when a combination takes place, and the spot appears quite black.

This metal dust sometimes gets into the paper when it is rolled between metal rollers. The purest photographic paper now manufactured is rolled between very hard paper pulp cylinders.

METAL SLIDES.—Dark slides or plate-holders made of sheet metal. They are very light and strong, and offer considerable safety against extraneous exposure.

METAMERIDES.—See **Isomerism.**

METEOROLOGICAL PHOTOGRAPHY.—Photography has already become an invaluable aid to the meteorologist in the preservation of accurate records, or of extraordinary phenomena.

METER.—A French measure of length equal to 39.3707898 inches, or about 3.2809 feet. The standard of linear measure being the ten millionth part of the distance between the Equator and the North Pole as determined by actual measurement of an arc of the meridian. (See **Metric System.**)

METHENYL CHLORIDE.—See **Chloroform.**

METHYLATED ALCOHOL.—See **Alcohol,**

METHYLATED ETHER.—See **Ether.**

METHYLATED SPIRIT.—See **Alcohol.**

METHYLCATECHOL.—See **Guaiacol.**

METHYLPYROCATECHIN.—See **Guaiacol.**

METOL. (Formula: $C_8H_{11}NO$.) Metol is the trade name given to the sulphate* of methyl-paramidometacresol. It takes the form of a whitish powder soluble in water. A solution of it with alkalies in presence of alkaline sulphites will remain colorless for a great length of time. Employed with alkaline carbonates it forms a very energetic developer for gelatino-bromide dry plates, or in a more diluted form it can be used for gelatino-chloride, or chloro-bromide gelatine plates.

CONCENTRATED METOL DEVELOPER.

Water	1,000 parts
Metol	15 parts
Crystallized sodium sulphite	90 parts
Potassium carbonate	45 parts

* Waterhouse is of opinion that it is more probably a phosphate or phosphite of this compound.

Instead of the potassium carbonate 120 parts of crystallized sodium carbonate can be used.

For portrait work this solution is diluted with an equal volume of water and for landscape work, with twice its volume of water.

METOL POTASH DEVELOPER.

A.

Water	1,000 parts
Crystallized sodium sulphite	100 parts
Metol	10 parts

B.

Water	1,000 parts
Potassium carbonate	100 parts

For use, mix three parts of A with one part of B. Development is usually complete in three minutes. For slow development and soft images use more water and less alkali.

METOL SODA DEVELOPER.

A.

Water	1,000 parts
Crystallized sodium sulphite	100 parts
Metol	10 parts

B.

Water	1,000 parts
Crystallized Sodium Carbonate	100 parts.

For use, take equal parts.

STOLZE'S FORMULA.

A.

Water	400 parts
Potassium metabisulphite——	45 parts
Metol	15 parts

B.

Water	400 parts
Potassium carbonate	15 parts

For use, add to 100 parts of water 20 parts of A and 20 parts of B.

The soda developer works slower than the potash, but both are suitable for portrait or landscape work. Potassium bromide acts as a restrainer though not so powerfully as with other developers, nor does it so much tend to produce hard images. Old developers can be used in cases of over exposure. The same developer can be used for development of several plates. Even after use it remains almost colorless for a long time. The image usually appears very rapidly with all its details and gains opacity afterwards.

Metol solutions have the effect of hardening the gelatine film so that a longer time is required for fixing. According to Larsoff, after the image has appeared, the film, while in the metol solution, is practically insensitive to white light, although the solution itself is colorless and transparent.

Metol can also be used for the development of positives on bromide paper. For this purpose Dr. Just recommends three stock solutions:

A.

Water	100 parts
Metol	1 part
Sodium sulphite	10 parts

B.

Water	100 parts
Potassium or sodium carbonate	10 parts

C.

Water	100 parts
Potassium bromide	10 parts

For sepia tones: Water, 84 parts; solution A, 6 parts; B, 1 part: C, a few drops. For red tones use 140 parts of water and more of C. For black tones give short exposures and use 60 of A to 10 of B and a few drops of C.

According to Col. Waterhouse old metol solutions can be detected by the decided and unmistakable smell of phosphorus they evolve.

METRIC SYSTEM.—The system adopted by the French Convention in 1879, but which is gradually coming into use in this and other countries. The theory of the system is that the meter is a 10,000,000th of a quadrant of the earth through Paris, the liter is a cube of $\frac{1}{10}$th meter, the gram is $\frac{1}{1000}$th of the liter filled with water at 4 degs. C.

The meter is a measure of length equal to 39.37 English or American inches.

This system, formed on the meter as the unit of length, has four other leading units, all connected with and dependent upon this. Hence, we have :

1. The meter, which is the unit of measures of length.
2. The are, which is the unit of surface, and is the square of the meter.
3. The liter, which is the unit of measures of capacity, and is the cube of a tenth part of the meter.
4. The stere, which is the unit of measures of solidity, having the capacity of a cubic meter.
5. The gram, which is the unit of measures of weight, and is the weight of that quantity of distilled water at its maximum density, fills the cube of a hundreth part of the meter.

Each unit has its decimal multiples and sub-multiples, that is weights and measures ten times larger, or ten times smaller, than the principal units. The prefixes denoting multiples are derived from the Greek, and are : Deka, ten; hecto, hundred; kilo, thousand, and myria, ten thousand. Those denoting sub-multiples are taken from the Latin, and are : Deci, ten; centi, hundred (as in centigram or centimeter), and milli, thousand.

The metric system has been adopted by many nations, the English excepted. In America its use has been made optional, but is legalized by Congress. All photographic formulæ received from the continent of Europe express values and quantities with metrical weights and measures. To utilize them directly without translating into the expressions of the English system, the student is advised to procure gram weights and cubic centimeter graduates, and substitute them for those denoting quantities according to the old plan.

As an assistance to those who cannot acquire these aids, we annex tables, which convert grams and cubic centimeters into English grains, drachms, and ounces sufficiently correct for practical purposes.*

Metric Fluid Measures.—The cubic centimeter, usually represented by "C.c.," is the unit of the metric measurement for liquids. It contains 17 minims of water. The weight of this quantity of water is 1 gram. The following table will prove to be sufficiently accurate for photographic purposes :

METRIC SYSTEM OF WEIGHTS AND MEASURES.

MEASURES OF LENGTH.

Denominations and Values.		Equivalents in Use.
Myriameter	10,000 meters.	6.2137 miles.
Kilometer	1,000 meters.	.62137 mile, or 3,280 ft. 10 ins.
Hectometer	100 meters.	328. feet and 1 inch.
Dekameter	10 meters.	393.7 inches.
Meter	1 meter.	39.37 inches.
Decimeter	1-10th of a meter.	3.937 inches.
Centimeter	1-100th of a meter.	.3937 inch.
Millimeter	1-1000th of a meter.	.0394 inch.

MEASURES OF SURFACE.

Denominations and Values.		Equivalents in Use.
Hectare	10,000 square meters.	2.471 acres.
Are	100 square meters.	119.6 square yards.
Centare	1 square meter.	1,550. square inches.

MEASURES OF VOLUME

Denominations and Values.			Equivalents in Use.	
Name.	No of Liters.	Cubic Measures.	Dry Measure.	Wine Measure.
Kiloliter or stere	1,000	1 cubic meter.	1.308 cubic yards.	264.17 gallons.
Hectoliter	100	1-10th cubic meter.	2 bu. and 3.35 pecks	26.417 gallons.
Dekaliter	10	10 cubic decimeters.	9.08 quarts.	2.6417 gallons.
Liter	1	1 cubic decimeter.	.908 quart.	1.0567 quarts.
Deciliter	1-10	1-10th cubic decimeter.	6.1023 cubic inches.	.845 gill.
Centiliter	1-100	10 cubic centimeters.	.6102 cubic inch.	.338 fluid oz.
Milliliter	1-1000	1 cubic centimeter.	.061 cubic inch.	.27 fl. drm.

* From *American Annual of Photography.*

WEIGHTS.

Denominations and Values.			Equivalent in Use.
Names.	Number of Grams.	Weight of Volume of Water at its Maximum Density.	Avoirdupois Weight.
Millier or Tonneau	1,000,000	1 cubic meter.	2204.6 pounds.
Quintal	100,000	1 hectoliter.	220.46 pounds.
Myriagram	10,000	10 liters.	22.046 pounds.
Kilogram or Kilo	1,000	1 liter.	2.2046 pounds.
Hectogram	100	1 deciliter.	3.5274 ounces.
Dekagram	10	10 cubic centimeters.	.3527 ounce.
Gram	1	1 cubic centimeter.	15.432 grains.
Decigram	1-10	1-10th of a cubic centimeter.	1.5432 grain.
Centigram	1-100	10 cubic millimeters.	.1543 grain.
Milligram	1-1000	1 cubic millimeter.	.0154 grain.

For measuring surfaces, the square dekameter is used under the term of ARE; the hectare, or 100 ares, is equal to about 2½ acres. *The unit of capacity* is the cubic decimeter or LITER, and the series of measures is formed in the same way as in the case of the table of lengths. The cubic meter is the unit of measure for solid bodies, and is termed STERE. *The unit of weight* is the GRAM, which is the weight of one cubic centimeter of pure water weighed in a vacuum at the temperature of 4 degs. Cent., or 39.2 degs. Fahr., which is about its temperature of maximum density. In practice, the term cubic centimeter abbreviated c.c., is generally used instead of milliliter, and cubic meter instead of kiloliter.

The following table for the conversion of metric into American measure has been computed by Dr. Nelson B. Sizer, and is true to the nearest half grain or minim, as the case may be, so it will prove a sufficiently near approximation to the required metric equivalents.

U. S. P. Standard.

Gram, or c.cm.	Grains.	Minims.	Gram, or c.cm.	Grains.	Minims.
1	15½	16½	15	231½	244
2	31	32½	16	247	260
3	46	49	17	262	276
4	62	65	18	278	292½
5	77	81	19	293	309
6	93	97½	20	308½	325
7	108	114	30	463	487½
8	123½	130	40	617	650
9	139	146	50	771½	813
10	154	162½	60	926	975½
11	170	179	70	1,080	1,138
12	185	194	80	1,234½	1,300½
13	201	211	90	1,389	1,463
14	216	227½	100	1,543	1,625½
.....	.....	.....	1,000	15,432½	16,256
.....	.....	.....	.....	1 kilo.	liter.

The "kilo" or kilogram, the 1,000 gram weight, is equal to 32 ounces $72\frac{5}{10}$ grains "Troy or Apothecaries" weight, or 2 pounds 3 ounces $119\frac{7}{10}$ grains Avoirdupois.

The "liter" or 1,000 cubic centimeters, or bulk of water that weighs 1 kilo, is equal to 2 pints 1 fluid ounce and $415\frac{5}{10}$ minims, U. S. P. Standard, or our glass graduates as commonly sold by reliable houses.

The grains and minims are easily reduced to fluid drachms and fluid ounces, or drachms and ounces Troy, by my readers, if they will only remember that 60 grains or minims go to the solid or fluid drachm, and 480 grains o. minims, or 8 drachms solid or fluid, go to each U. S. P. ounce, solid or fluid.

Thus the table gives the value of 90 grams as 1,389 grains, of 90 cubic centimeters as 1,463 minims. How many ounces in each?

Dividing 1,389 by 60 for drachms, we have 23 drachms 9 grains. As 8 drachms go to the ounce, there are 2 ounces in the 23 drachms and 7 drachms over, so we have—in 1,389 grains there are 2 ounces 7 drachms 9 grainsr In the same way we find 3 fluid ounces and 23 minims over, to be the value of 90 cubic centimeters or 1.463 minims.

MEZZO RELIEVO.—See **Alto Relievo.**

MICA.—A mineral of a foliated structure, consisting of thin flexible laminæ or scales, having a shining, pearly, and almost metallic luster. It enters into the composition of the crystalline rocks. Owing to its peculiar transparency and flexibility it has often been used in place of glass, especially in places where it is subjected to great heat, which has no immediate effect upon it; for instance, in the windows of stoves and lanterns, in chimneys for lamps, and as a substitute for glass in silvered reflectors, which are exposed to great heat.

Various attempts have been made to use it as a substitute for glass in photography, but these have been unsuccessful, owing to its peculiar property of splitting up into fine sheets, some of which are not more than the $\frac{1}{0000}$ part of an inch thick.

Dark room lamps having chimneys of mica, colored with a suitable red varnish, will be found very serviceable, and can be carried about with safety without fear of cracking.

MICRO-PHOTOGRAPHY.—The production or reproduction of positives in a very minute size, requiring the aid of a miscroscope or magnifying glass to examine them. This term is often

erroneously confounded with photo-micrography—the product of photographic images of microscopic objects.

Micro-photographs were at one time exceedingly popular, and are still sold at seaside and other holiday resorts, usually fixed behind a small magnifying glass in some fancy article such as a penholder or a paper-knife. The collodion process is generally employed in their manufacture. An apparatus that will be found cheap and convenient is the following, a description of which is given in Sutton's "Dictionary of Photography." It was devised by Mr. Hislop, and consists of a rigid mahogany board of about three and a half feet long and six inches wide. At one end there are two uprights, between which a miniature camera fitted with a one inch microscopical objective can be raised up or down so as to place the center of the lens opposite the center of the negative, whatever may be its size. The object glass is screwed to a brass tube projecting from the camera towards the negative, the tube being fitted with stops of different sizes. A micrometer head for fine adjustment of the lens is also necessary, because microscopic objectives are only corrected for visual rays. In focusing, the best glass is one coated with collodion, sensitized and washed. The sharpest visual image must be found with a powerful magnifying glass, and the chemical focus ascertained by repeated trials. When once found, it will be the same in every case, provided the negative is placed at the same distance from the objective. The negative itself is placed in a frame, at any required distance, on the long mahogany board, but its plane must be perpendicular to the axis of the tube holding the negative. Illumination may be either natural or artificial, but must, of course, pass through the negative.

The collodion used for making the sensitive plates must be absolutely free from structure, or the images will have a disagreeable reticulated appearance when examined under the microscope. For the same reason a pyro developer should be used, instead of the protosulphate of iron, as the former gives a much finer silver deposit.

Another process that may be employed is the collodio-albumen.

MIDDLE DISTANCE.—The central position of a landscape, also called *middle-ground.*

MILITARY PHOTOGRAPHY.—Photography was employed for military purposes as far back as 1854, when, during the Crimean war, two army officers were specially instructed for the purpose in the wet and dry collodion processes. The results obtained are said to have been so satisfactory as to lead to the establishment of a photographic department in nearly every military college, where men are taught the principal branches of photography.

The introduction of the gelatine dry plate process has caused photography to be of great assistance for military purposes. Officers reconnoitering carry with them light cameras, with which they make views to accompany the report of the reconnaissance.

The plan of making photographs during their work has already been successfuly adopted by engineers so as to convey to those in command accurate information regarding the progress made.

During the Franco-Prussian war homing pigeons were used for the conveyance of letters from the besieged city of Paris. This could hardly have been accomplished without the aid of photography. The messages were all photographed on the collodion films, which were afterwards stripped from the glass. Each film contained no less than 8,000 words, and about twenty or thirty of these were fitted in a small quill tied to the tail feathers of the pigeons. The weight of the whole was less than 15 grains, and did not at all impede the bird in its flight. When these messages were received they were, of course, so small as to be perfectly illegible, but when thrown on to a screen by means of a magic lantern, they could be read with ease.

Photographs were made from captive balloons during the United States rebellion, which showed not only the disposition of the troops, but also the topographical features of the surrounding country. MM. Tissandier and P. Nadar have both been successful in making photographs from a balloon.

The late W. B. Woodbury constructed and patented a balloon camera especially adapted for war purposes. A small balloon only was necessary to carry the camera. which was operated by the officer on *terra firma* by means of an electric current passing through the rope that held the balloon captive. By this means photographs could be made showing the positions and movements of the enemy without risk of life, which was the case when men ascended with the balloon, which was necessarily large, and offered a good target for the enemy.

At the Engineers' School of Photography at Chatham, England, photographs are made of the various articles furnished for field use, and also all experimental structures, whether in the shape of shields, guns, small arms, wagons, rockets, etc. "The results of firing experimentally against plates of different thicknesses are reproduced and preserved; instructional pictures showing the methods of making guns of different descriptions, and the positions taken up by individual gunners on the issue of the various orders are taken; photographs exhibiting the regulation mode of wearing accoutrements; the precise manner in which the harness of horses is adjusted; the method of packing wagons, and fitting service saddles; the mode in which military tents and equipage are set up, as well as the preparation of pictures of newly-adopted stores and implements are among the duties fulfilled at the department.

There is no doubt that should a great war break out, photography would play a very important part.

MILK GLASS.—A semi-translucent glass used in graduated measures and other instruments to contain the scale in order to render it more legible.

MILLIGRAMME.—The one-thousandth part of a gramme (see **Metric System**).

MILLILITRE.—A measure of volume according to the metric system. It is the thousand part a liter, and equal to 16 9 minims.

MILLIMETRE.—A measure of length according to the metric system. It is equal to the thousandth part of a metre, or the .3937 of an inch.

MINERAL NAPHTHA.—See **Naphtha.**

MINERAL PITCH.—See **Asphaltum.**

MINIM.—See **Weights and Measures.**

MINIMUM THERMOMETER.—A thermometer so constructed as to register the lowest temperature during a day or at any given interval of time.

MIRROR.—Literally any glass or polished substance which forms images by the reflection of the rays of light. Mirrors are mentioned in the book of Job (chap. xxxvii., verse 18). Those of the ancient Egyptians were of bronze, several of which are preserved in the British Museum. Mirrors of polished metal are now termed *specula*. The date of the invention of glass mirrors is not known with certainty. From the account of Pliny, it would seem that they had been formerly made at the celebrated glass-houses of Sidon.

Mirrors are either plane, concave, or convex. Plane mirrors represent objects of their natural size, concave mirrors, or those having a hollow surface, collect the rays, reflecting them to a focus in front of the mirror, and consequently enlarge the image of the object. Convex mirrors disperse the rays, and therefore diminish the size of the image of the object. In photography, mirrors are chiefly used for reflecting light (see **Reflector**) and for reversing (see **Mirror, Reversing** and **Optics**).

FIG. 277.– EFFECT OBTAINED WITH PARALLEL MIRRORS.

MIRROR CAMERA.—A camera devised by Draper in which the image is reflected on to the ground-glass, or separate plate. See Fig. 278.

MIRROR PHOTOGRAPHY.—Quite a number of novel effects can be obtained by the aid of one or more mirrors. If two mirrors are taken and placed parallel to one another, and a person placed between, the effect obtained is as shown in Fig. 277, where one soldier appears as a whole regiment drawn up into line. To make this experiment we require two large-sized mirrors, and they must be so arranged that they do not reflect the camera and the photographer, but give only multiple images of the sitter. This will be found quite possible, all that is necessary is to make a few preliminary experiments, adjusting the mirrors at different angles until the desired effect is obtained.

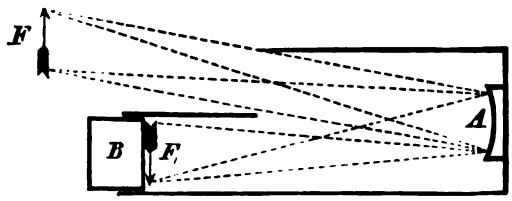


FIG. 278.

A process of multiphotography which was at one time quite popular consisted in posing the sitter with his back to the camera as shown in Figs. 280 and 281. In front of him are arranged two mirrors, set at the desired angle to each other, their inner edges touching. In the illustrations here given the mirrors are inclosed at an angle of 75 deg , and five reflecting images are produced. When an exposure is made and the negative developed, we not only have the back view of the sitter but the full reflected images in profile, and three-quarter positions as well.

In the diagram, Fig.279, reproduced from *The Scientific American*, the courses taken by the

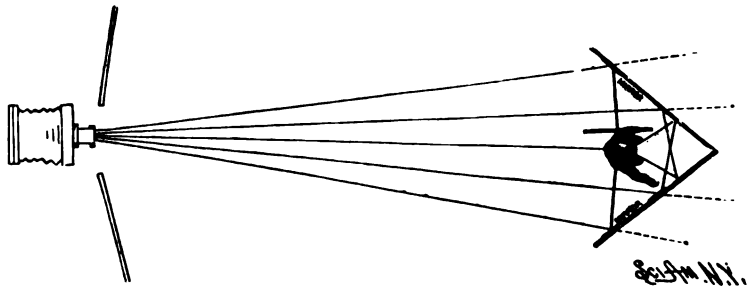


FIG. 279. DIAGRAM SHOWING HOW FIVE IMAGES ARE PRODUCED.

rays of light determined by the law that the angle of incidence is equal to the angle of reflection is plainly marked out. We see here their passage from the sitter to the mirror and back to the camera. Provided the mirror be large enough images of the full length figure can be made as shown in Fig. 281.

For photographing articles where it is of advantage to secure a number of different views of the same object this method of photographing with mirrors opens up quite a wide field of possibilities. In France it is used for photographing criminals, and thus obtaining a number of different portraits with one exposure.

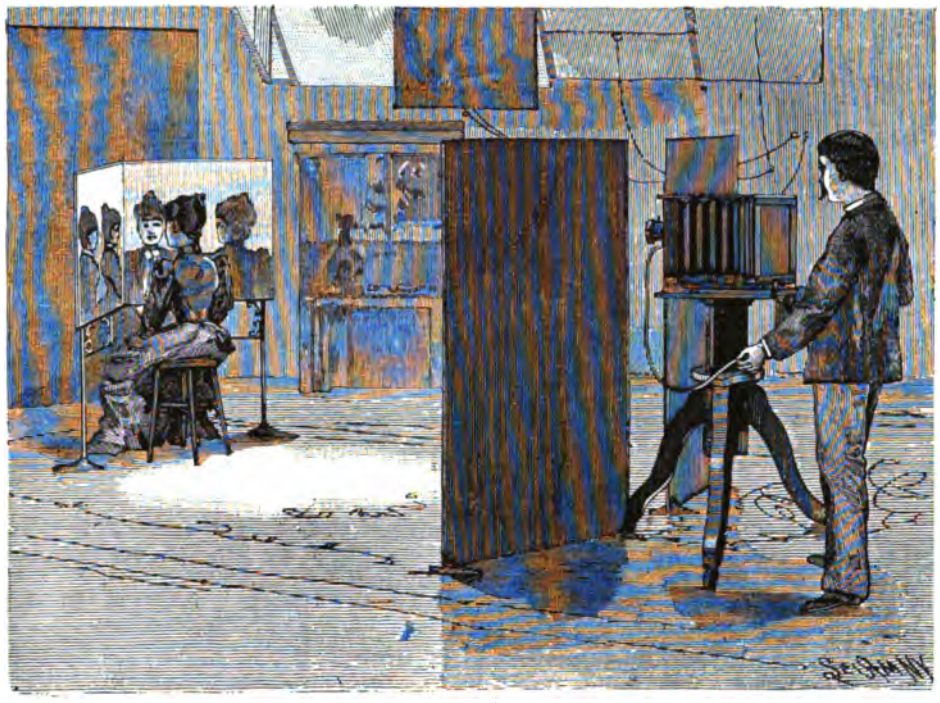


FIG. 280. GALLERY ARRANGED FOR MULTI-PHOTOGRAPHY.

The use of an ordinary mirror in portrait work has enabled photographers to produce very pleasing results. There is often a very striking difference between the full and side views of a person's face, and by means of such a combination as this, one is enabled to secure a perfect representation of both at the same time. In making reflection portraits it has often been noted that the reflection has a more pleasing effect than the direct portrait. The reason of this is that it is softer, and the facial blemishes are not so distinctly brought out. There is naturally a slight loss of detail, but this is by no means a drawback. The worst fault of the camera in portrait photography is the tendency to include every little detail which the artist would suppress. It not only includes all the detail but often exaggerates it to a painful extent. By making a portrait by reflection this defect is avoided. Of course the image is reversed, but this is in most cases of little consequence; in fact the sitter himself would be more likely to consider it a far more truthful likeness, for when we look into a mirror we do not see ourselves as others see us, but a reversed image. With some faces the difference is quite striking.

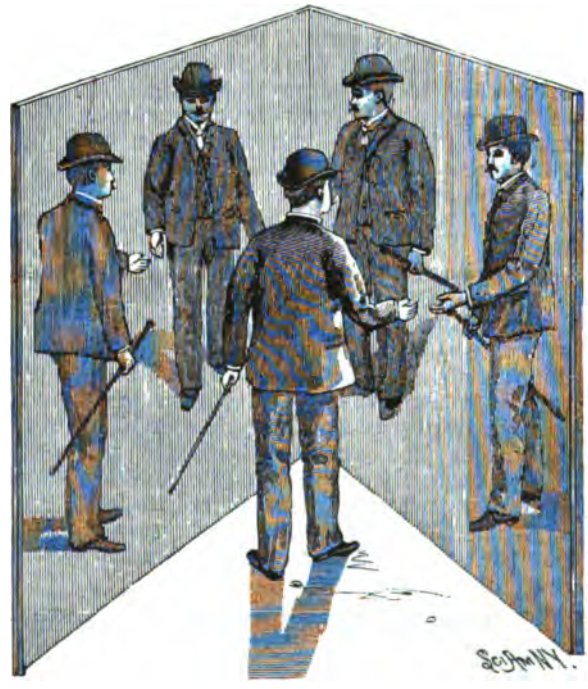


FIG. 281. MULTI-PHOTOGRAPH OF A FULL LENGTH FIGURE.

Very many amusing effects can be obtained by the use of a convex mirror. Even an ordinary, well-polished spoon may be made to give some curious results. The thin man becomes an oblongated mass of humanity that Barnum would have given a big salary to, while the fat may be reduced to the proportions of a walking-stick.

Convex mirrors for producing these ludicrous effects can be purchased at any mirror manufacturer's store. The advantage of the camera lies in the ability to secure permanently the curious images produced.

By L. H. Bostwick.

FIG. 282. MULTI-PHOTOGRAPH.

Even more ridiculous-looking images can be secured by the use of a piece of uneven glass silvered. For a method of silvering glass we are indebted to the kindness of Dr. James H. Stebbins, Jr., the well-known analytical chemist. Dissolve pure nitrate of silver in distilled water in the proportion of 10 grains to 1 ounce, and add carefully, drop by drop, sufficient strong ammonia solution to just dissolve the brown precipitate at first formed, stirring constantly during the addition.

Make a solution of Rochelle salts, 10 grains to the ounce of distilled water. Clean the plate of glass thoroughly with a little wet rouge and polish dry with a piece of chamois leather. Warm it before the fire or in the sun to about 70 to 80 deg. Fahr., and lay it on a perfectly level surface. Then mix 1 ounce of the silver solution with half an ounce of the Rochelle salt solution and pour the mixture on the glass, so that every part of the surface will be evenly covered with it.

Allow this to stand in the warm sunshine from half to one hour, when the reduced silver will be deposited as a fine film over the surface of the glass. When this is done wash off the glass with distilled water and wipe the entire surface very gently with a little wet wadding, which will take off the roughness and render it easier to polish. When perfectly dry the silver should be polished by rubbing with some smooth, hard surface. The plate is then varnished by pouring over it a suitable varnish and is ready for use.

FIG. 283. EFFECT OBTAINED WITH A CONVEX MIRROR.

MIRROR, REVERSING.—A plane mirror arranged at an angle of 45 deg. and placed close to the lens. The image in this mirror is then photographed, and a reversed image is obtained. (See **Reversed Negative.**) The mirror used for this purpose must be perfectly flat, or the image will be distorted. Ordinary looking-glass will not answer the purpose, as its reflecting surface is at the back, and we get a faintly reflected image from the glass surface as well.

MIRROR, SILVERING.—The following recipes may be found useful by those desiring to re-silver mirrors or reflectors :—

Martin's Recipe for Glass.

A.

Nitrate of silver	175 grains
Distilled water	10 ounces

B.

Ammonium nitrate	262 grains
Distilled water	10 ounces

C.

Pure caustic potash	437·5 grains
Distilled water	10 ounces

D.

Pure sugar candy	219 grains
Distilled water	5 ounces

dissolve and add

Tartaric acid	50 grains

Boil in a flask for ten minutes, and when cool add

Alcohol	1 ounce
Distilled water to make	10 ounces

For use, mix together equal parts of A and B and also equal parts of C and D in anothe. flask, then mix the two solutions in the silvering vessel and suspend the mirror face downwards

H. F. Burton's.

Solution 1.

Nitrate of Silver	25 grains
Distilled water	1 ounce

Solution 2.

Potash (pure)	25 grains
Distilled water	1 ounce

Solution A.

Solution 1)	
Solution 2)	equal parts
Ammonia	to just dissolve the precipitate
Solution 1	to just cause a discoloration.

Section B.

Loaf sugar	2700 grains
Distilled water	20 ounces
Nitric acid	2 drachms
Alcohol strong	10 ounces
Distilled water to make	80 ounces

For use—

Solution A	1 ounce
Solution B	1 drachm

Solution A is subject to slow decomposition ; Solution B, on the contrary, improves by keeping.

Metal to be silvered must be previously well cleaned with dilute acid, to remove all dirt or grease, then well washed and the following applied with a piece of flannel :—

Silver nitrate	55 grains
Liquor ammonia	60 grains
Sodium hyposulphite	100 grains
Prepared chalk	100 grains
Distilled water	1000 grains

Or this—

Silver nitrate	60 grains
Cream of tartar	120 grains
Salt	110 grains
Potassium cyanide	65 grains

Made up into a paste with chalk and water, and applied with a soft rag.

MIXTOL.—A developing solution composed of—

Water	1000 parts
Sodium sulphite	120 parts
Quinol	15 parts
Eikonogen	10 parts
Potassium ferrocyanide	20 parts
Potassium carbonate	75 parts
Caustic potash	15 parts
Potassium bromide	1 parts

And a small quantity of glycerine.

MOONLIGHT EFFECTS.—Curious as it sounds, very good moonlight effects can be procured on a bright sunshiny day. A photograph is made of a landscape in dazzling sunlight, a small stop and rapid exposure being given. The plate should, if possible, be backed with any of the substances recommended to prevent halation. Choose a landscape, with the reflection of the sun's rays in water, and include this and the sun itself on the plate. It is best to wait, however, until the sun just disappears behind a cloud. Shade the lens so that the rays do not shine on it direct, and expose rapidly. Use an old or weak developer. The sun and its reflections will, of course, make their appear: ance first. Continue the development until the detail in the under-exposed parts is just visible, and fix. Print very darkly, and slightly over tone. If printing is done upon green albumenized paper, and a little re-touching with Chinese white, the effect is very good.

FIG. 284.

PHOTOGRAPH MADE BY MOONLIGHT BY F. A. DEMUTH

MOIST COLLODION PROCESS.—About the year 1854* Messrs. Spiller and Crookes proposed to keep the collodion moist by the use of a deliquescent salt, *i.e.*, some substances possessing a strong affinity for water, and would absorb moisture from the air. The substancec experimented with were the nitrates of lime, magnesia, and zinc. The glass plate collodionized and sensitized in the usual manner was immersed in a solution of zinc nitrate and silver nitrate for five minutes. After draining for a half-an-hour on blotting paper the plates were ready for use.† Owing to the hygroscopic nature of the salt, the plates remain moist, and could be used a week or so after preparation. Nitrate of magnesia was found preferable to zinc nitrate.The plates could also be kept after exposure, but it became necessary to again dip them into the silver bath previous to development

MOONLIGHT PHOTOGRAPHY.—With gelatine dry plates of extreme sensitiveness it is possible to make photographs by moonlight, only a very long exposure is required. Fig. 284 is a good example of moonlight photography. It was made by Mr. F. A. Demuth with a Bausch & Lomb R. R. Lens *f*8, Seeds 26 x plate, and one hour's exposure from 8.15 to 9.15 on a February night.

MOUNT.—The cardboard or other support to which the photograph is attached. These are of various kinds.

Portrait Mounts.—These are usually of enameled cardboard, with plain, beveled, or gilt edges. The quality depends upon the composition of the board, the thickness (which is usually determined by the number of sheets the card is made up of) and the finish.

* See *Philosophical Magazine*, May, 1854. † Harrison's *History of Photography.*

FIG. 285.—MOONLIGHT EFFECT PRODUCED BY PHOTOGRAPHY. BY E. EVELYN BARRON.

Cheap mounts are never to be recommended. The card used often contains impurities that are fatal to the permanency of the photograph and consequently detrimental to the interests of the photographer. The edges are also finished off with a bronze paste; often this finds its way to the surface of the mount and produces small white spots in the photographic image. Pure boards finished with real gold leaf should always be employed.

Portrait mounts are usually of various colors. Black, dark green, and olive are very effective. White or light colored mounts are more suitable for some subjects, but these soon become dirty in handling, and never bear a nice appearance for any length of time.

The various sizes of portrait mounts are as follows:

Stereoscopic..	3½ by 7, 4 by 7, 4½ by 7, 4½ by 7, 5 by 8	Minette.....	1½ by 2⅝
Victoria.....	3½ " 5	Card.....	2½ " 4⅛
Imperial	7½ " 9½	Cabinet.....	4½ " 6½
Boudoir.....	5½ " 8½	Promenade	4½ " 7⅛
Panel	4 " 8½		

View Mounts.—These are of various kinds and should be much larger than the photograph to be mounted. They can be obtained in any size and quality, with and without a border line for the picture.

Cut Out Mounts.—These have a plain beveled or beveled and gilt opening, behind which the photograph is attached. They are very effective and especially suitable for gelatino chloride prints, as by their use the mountant is only applied to the edges, and so the glossy surface remains unimpaired.

The permanency of pictures mounted in this way is also liable to be greater, as there is no mountant to have a deleterious action as many do.

Plate-Sunk Mounts.—These are produced by pressing a portion of the center of the mount with a metal plate, so that that part has a sunken-in appearance. The plate-sunk portion should be a little larger than the picture to be mounted. Mounts of this description can be purchased ready-made in the standard sizes. If any unusual size is desired, it can be made by cutting a piece of sheet metal to the size required, laying it on the plain cardboard mount and applying to it considerable pressure in an ordinary letter-copying press.

Paste-Down Mounts.—These are made by pasting a sheet of paper of a different tint, to the center of the mount. A white mount with a gray paste-down a little larger than the picture, or a gray mount with a white paste-down are very effective for platinotype or matt surface prints.

Plate-Sunk Paste-Down Mounts.—These have a plate-sunk mark in the center, and in this is attached the paste-down, somewhat smaller than the plate mark and larger than the photograph. They combine the beauties of the plate-sunk mount, with the paste-down.

Oxford Mounts.—Plain mounts having a border line round the photograph, finished off at the corners like the Oxford frame, thus—+.

MOLECULAR WEIGHT.—The weight of the smallest particle of a compound that can exist. It is found by adding together the weights of all the atoms of the several elements which have united to form the molecule of the compound body.

MOLECULE.—The smallest part of a substance capable of separate existence and able to retain its composition and properties—the smallest quantity of two or more atoms forming a given chemical compound.*

MONOCHROMATIC.—Consisting of one color only. Monochroic.

MONOCHROMATIC LAMP. —A lamp emitting rays of one refrangibility only. By introducing into a colorless spirit or gas flame a tuft of asbestos, saturated with chloride of lithium, sodium, or thalium, a red, yellow, or green-colored light can be produced.

MONOCLE.—Under this term have been introduced uncorrected spectacle lenses, which have been strongly recommended for portraiture and ordinary landscape work where softness of definition is desired. The usual form of lens employed is the periscopic of about 1½ inch diameter, and may be obtained of any focus from about 2 inch and upwards. These lenses, being uncorrected, necessarily have two foci, a chemical and visual, and it is therefore necessary to make a correction after focusing and before exposing. For ordinary landscape work the required correction may be made by means of the formula $f = f0{\cdot}02$, which is practically equal to $\frac{1}{50}$th of the focus. But this only applies when the lens is working at its equivalent focus. The following table gives the necessary correction for varying foci and sizes of images :†

TABLE SHOWING THE CORRECTION FOR ACTINIC FOCI WITH MONOCLES OR SPECTACLE LENSES.

PROPORTION BETWEEN IMAGE AND OBJECT.

	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$	$\frac{10}{10}$
f 100	100	120	130	140	150	160	170	180	190	200
f 2	2·4	2 9	3·4	3·9	4·5	5·1	5·8	6.8	7·2	8·0
f 150	165	180	195	210	225	240	255	270	285	300
f 3	3·6	4·3	5·1	5·9	6 8	7·7	8·7	9·7	10·8	12·0
f 200	220	240	260	280	300	320	340	360	380	400
f 4	4·8	5·8	6·8	7·8	9·0	10·2	11.6	13·0	14·4	16·0
f 250	275	300	325	350	375	400	425	450	475	500
f 5	6·1	7·2	8·5	9 8	11·3	12·8	14·5	16·2	18·1	20·0
f 300	330	360	390	420	450	480	510	540	570	600
f 6	7·3	8·6	10·1	11·7	13·5	15·4	17·3	19·4	21·7	24·0
f 350	385	420	455	490	595	560	595	630	665	700
f 7	8·5	10.1	11·8	13·7	15·8	17·9	20·2	22·7	25·3	28·0
f 400	440	480	520	560	600	640	680	720	760	800
f 8	9·7	11·5	13·6	15·7	18·0	20.5	23·1	25·9	28·9	32·0
f 450	495	540	585	630	675	720	765	810	855	900
f 9	10·9	13·0	15.2	17·7	20·3	23·0	26·0	29·2	32·7	36·0
f 500	550	600	650	700	750	800	850	900	950	1,000
f 10	12·1	14·4	16·9	19·6	22·5	25·6	28·9	32·4	36·1	40·0

MONOCULAR VISION.—Sight with one eye only.

MONOSTEREOSCOPE.—An arrangement described by Tissandier,‡ and said to be the invention of Claudet. It consists of a dark screen, the center of which has been cut out and the space occupied by a piece of ground glass. By means of two optical lanterns two images of the same object are "so combined as to give the impression of the picture being in relief." We, however, fail to see how this effect could be produced in this manner.

* The approximate weight of a molecule of hydrogen is given by an eminent authority as 0,000,000,000,000,000,000,000,000,04 of a gramme; multiplying this inconceivably small number by 55, the atomic weight of iron, the weight of a molecule of iron is ascertained—0,000,000,000,000,000,000,002,2 gramme. In the sulphocyanide test the presence of thirty-three ten millionths of a gramme of iron is detected; dividing this number by the weight of one molecule of iron, it seems that this apparently delicate test is unable to indicate to our senses a less number than 1.500,000,000,000,000 molecules.

† Wall's Dictionary of Photography.

‡ The History of Photography, by Gaston Tissandier.

MOTION, PHOTOGRAPHING.—The representation of motion by photography is by no means an easy task. Artists manage to give us pictures in which we get motion depicted, yet some will tell you that these are wrong entirely.

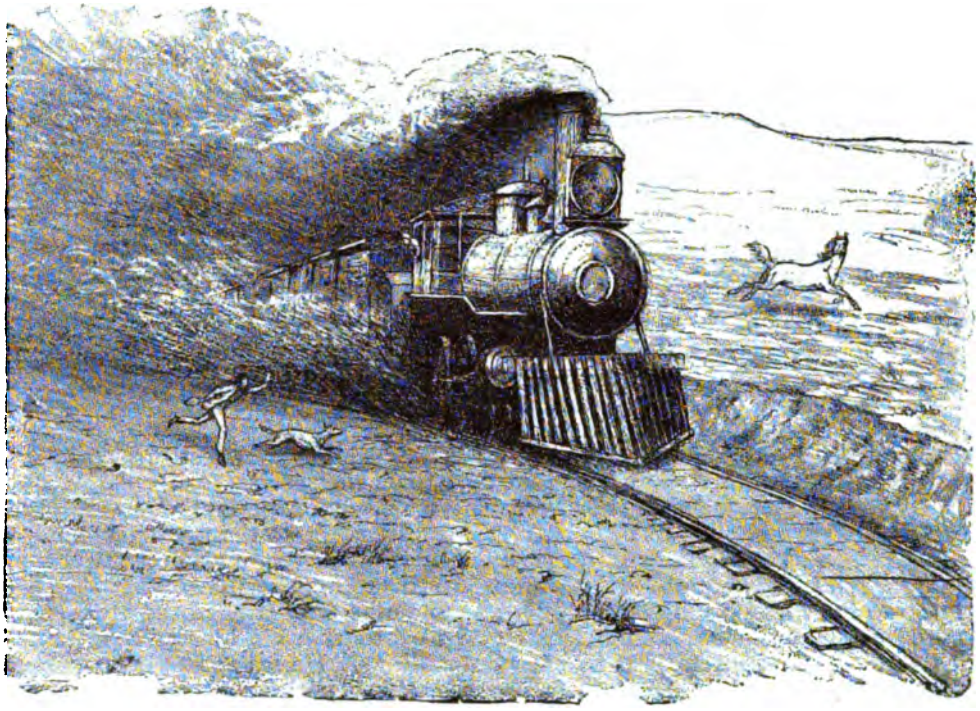


FIG. 286.

The artist has made a horse galloping; it appears to our eye to be performing this action, yet the instantaneous photographer will come forward and say: "No! that is utterly wrong; a horse never assumes that position; here are the motions he goes through," and that we see a number of photographs taken one after the other and representing the various phases of movement performed by the animal in galloping or jumping. But with none of these do we seem familiar. The horse in all these has an ungainly look, differing very much from the graceful movement we believe in. Why is this?

Again we see instantaneous photographs of a man walking. He is caught by the camera with one leg in the air and the other on the ground. Does he look as if he is walking? Not a bit of it. He appears to be practising the goose step with the body motionless. Take another example—an express train going at the rate of fifty miles an hour. Look at an instantaneous photograph taken in the—goodness knows what—fractional part of a second? Does it look as if the train is traveling at that speed or at thirty miles an hour, or twenty, or ten, or one? Does it look as if it is moving at all?

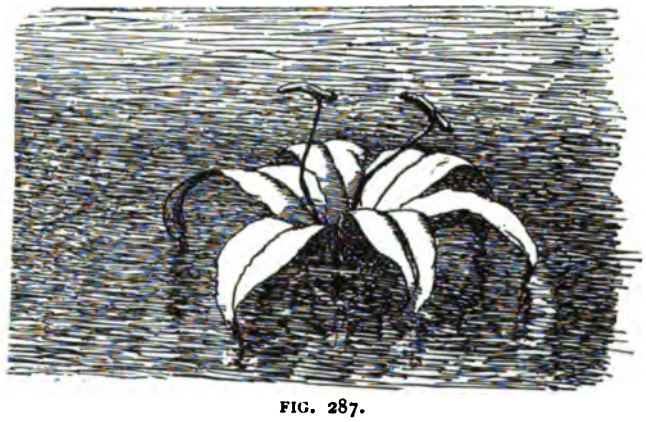


FIG. 287.

FIG. 288.

Sometimes it occasionally happens that we find a photograph giving us some idea of action, but we must admit that such are but rarely seen.

In a book entitled "Action in Art," by William H. Beard,* the author says: "What the latter has chiefly to learn is the difference between the eye and the camera. Many articles have been written upon the likeness of the eye to the camera, but these two differ in one essential point, and upon this point rests to a very large extent the cause of instantaneous photographs not ap-

* Published by Cassell Publishing Co., New York.

pearing to give us that idea of motion which we see, or imagine we see, with the eye.

Objects before the camera have their image thrown upon the dry-plate.. If they are moving we are obliged to give a very short exposure, in order to secure a sharp image. Thus we get a picture illustrating one phase of movement. Now this may, and most often is, an unfamiliar one, and why? For this reason: Objects before the eye have the image thrown upon the retina and the sensations are conveyed to the brain. Now the longer an object appears, or the greater the number of times that we see it, the more familiar we become with its appearance. Therefore we become most familiar with that phase of movement which we see most often, or for the greater length of time; for instance, in a galloping horse there are many movements performed which, having no prolonged periods or any distinctive characteristic, leave no impression on the mind. If in our instantaneous photograph we have secured one of these, the picture appears to us to be false, and gives us no idea whatever of motion, or of the horse in the act of galloping."

FIG. 289.

"The functions of an artist," says Mr. Beard, "are to find the various points in an action that leave their impress, and so combine and arrange them in a single form that the sense of movement shall be maintained." This the artist of ability can do, but with the photographer it becomes a far more difficult matter. The exposure is required to be so quickly performed that where the motion is rapid no selection can possibly be made, and he is required to work entirely without power of selection and take his chance on the result.

FIG. 290.

There are a few points, however, where a study of the methods employed by artists in the depicting of motion would be of considerable advantage to the photographer.

We have already instanced the difficulty in obtaining a photograph of a railway train in motion. Let us see how an artist works. In the accompanying illustration (Fig. 286) Mr. Beard gives us a locomotive which we cannot imagine otherwise than to be traveling at a high rate of speed. On examining the picture carefully we see that his idea is represented not so much by the image of the train itself as by the surroundings. He says: "The smoke and dust raised by the rapid train are essential features in the matter of movement, and the more useful because so much within the artist's control. Either or both may be formed into impenetrable masses as they are carried back by the pressure of the air, and made entirely to conceal or partially obscure obdurate lines and angles as the artist deems best for his purpose, and finally mingling together for a misty background from which the engine and train seem to emerge with unexpected suddenness." In the illustration the boy and dog running at their utmost speed, and the frightened horse galloping away, all are there to help the idea of motion. Turner, in one of his great works, places a little hare on the track flying for its life, and this gives us what is intended. Thus we see that the artist, by building up his picture, and making these additions, which, although apparently trivial, are essential features to preserve the idea of motion, gives us what we wish to represent. The photographer can do little, if anything, in this direction, so that we may as well give up the idea of ever obtaining a photograph of an express train which will really appear moving at a high rate of speed.

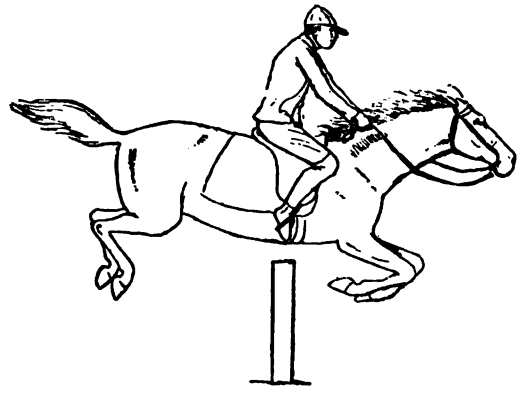


FIG. 291.

There are other instances where the artist is almost as incapable of representing action as the photographer.

In an interesting chapter entitled "Action that Cannot be Represented," the author says: "Motion can only be well represented within one medium. In passing from one into another the surface line of the denser medium forms an effective bar to further progress." As an illustration he gives a diver entering the water, and the spash and humorously likens his stationary appearance to a dilapidated lily with the two stamens floating upon the surface (Figs. 287 and 288).

How many photographs do we see of divers entering the water that have just the same appearance as that depicted? They do not represent action in any shape or form.

Speaking of Muybridge's celebrated photographs of animals in motion, he shows how few of the various phases gives the impression of action. Taking the greyhound for example, the greatest possible expression of speed is obtained when the animal has all feet free from the ground (see Fig. 289). In the next illustration (Fig. 290), no motion is expressed. The animal appears to be endeavoring to balance himself on one foreleg planted firmly on the ground, and pointing aimlessly in the air with the other.

Referring to Muybridge's horses, he says: "In the many impressions of horses leaping over hurdles, scarcely one seems able to clear the obstacle. The photograph arrests the motion

and leaves the creature in dangerous proximity to the obstruction (Fig. 291). Seeing the animal so distinctly, the mind cannot allow for the great swiftness of actual movement, and the artist's picture will give no better result unless he takes the liberty with facts to make the necessary allowance which the truthful camera cannot do. The mind must be freed from all apprehension of contact or the certainty of the action is unpoised by the fear."

MOTTLING.—This defect was at one time usually caused by inequality in the gelatine film, but at the present date dry plates are made all but perfect, and the cause must be looked for elsewhere. In most cases it proceeds from stagnation of the developer.

MOUNTANT.—The substance used for attaching prints to the mount or other permanent support. In the selection of a suitable mountant, it is necessary to avoid any that show any trace of acidity. It should be as simple and as free from foreign matter as possible, otherwise it is likely to have a detrimental effect upon the image, causing it to fade away. Among the many substances used for this purpose, owing to their adhesive properties, may be mentioned flour or starch paste, arrowroot, albumen, indiarubber solution, dextrine, gum, gelatine, glue.

Flour Paste.—Ordinary household flour makes an excellent paste, but it is rather liable to acidity. The following recipe for a paste that will not sour is given in "Spon's Recipes": Dissolve four teaspoonfuls of alum in one gallon of water; when cold stir in as much flour as will give it the consistency of thick cream, beat smooth, add one teaspoonful of pulverized resin, and 20 drops of oil of cloves, pour the whole into two quarts of boiling water, stirring thoroughly until it is cooked, pour into a glazed earthen vessel, and when cold cover the top with oiled silk, and put in a cool place. When needed for use, take out a portion and soften with warm water. This will be found very convenient for use at times when only a small quantity of paste is required.

The ordinary method of making a flour paste is to just pour boiling water on to a small quantity previously made into a paste with cold water.

Starch Mountant.—Starch, although much employed as a mountant, should be carefully used. Unless quite pure and fresh it is very dangerous, as it is very likely to become acid and destroy the print upon which it is laid.

It is best prepared by triturating starch with cold water in a mortar, so that it shall be perfectly free from lumps. Boiling water is then poured on slowly, constantly stirring the while until the paste is formed, which will be seen by its increased transparency. The addition of a little alum to the water with which it is prepared will render the paste more permanent. The proportions would be as follows: Powdered starch, two ounces, mixed with two ounces of water, and about 18 ounces of boiling water poured on, into which it has been dissolved about 50 grains of powdered alum, and 12 drops of carbolic acid.

Another formula is: Starch, 2 ounces; white glue, 1 ounce; acetic acid, ½ ounce, and a few drops of oil of cloves. The glue is first soaked in cold water, melted, and boiled, and while boiling the starch mixed with cold water is added.

Arrowroot Mountant.—The following has been given as a good recipe:

Best Bermuda arrowroot	3½ ounces
Gelatine (Nelson's No. 1)	160 grains
Methylated spirits	2 ounces
Carbolic acid (pure)	12 minims
Water (cold)	30 ounces

Mix the arrowroot into a stiff cream with a portion of the water, while the gelatine is placed to soak in the remainder. When the gelatine is softened, and the arrowroot well mixed, pour all together into an iron saucepan and bring to the boiling point. Keep at this heat for about five minutes, being particularly careful to stir continually from the moment the mixture is placed on the fire. When sufficiently cooked, pour into a basin to cool. When cool, add the carbolic acid and spirit (previously mixed) in a thin stream with constant stirring; then bottle, and keep well corked.

Albumen has been recommended as a mounting medium. The method of preparing a solution will be found given in the directions for preparing albumenized paper.

Gum is a very adhesive medium. A pale-colored gum arabic is used. Take about four ounces, and dissolve it in about eight ounces of distilled water. If the gum has a dirty appearance it should be previously washed in a little cold water to remove all impurities. When dissolved in the distilled water it can be kept in well-filled bottles tightly corked. If required to be kept for any length of time the addition of a small quantity of salicylic acid will act as a preservative. It will then keep for fourteen or fifteen days. If hot water be used to dissolve quickly its keeping properties are considerably lessened.

Dextrine Mountant.—Formula:

White dextrine (pure)	1 ounce
Boiling distilled water	3 ounces
Methylated spirit	½ ounce

Pour the boiling water on the dextrine and dissolve. Then add the spirit, and strain through fine muslin or calico.

India-rubber Solution has been often recommended as a mountant, the only drawback to its employment is its liability to become dry and crumbly, causing the picture to leave its support. The method of its production is to dissolve pure masticated rubber in about forty times its weight of chloroform or benzole.

Gelatine and Alcohol Mountant.—This is a very favorite one with amateurs, owing to its simplicity and cleanliness. The method of preparing it is to soak about one ounce of gelatine in ten ounces of water. When it is thoroughly swollen it is melted by gradual heat in a water vessel, and about four ounces of methylated alcohol slowly added, well stirring the solution during the addition. If required to be kept for any length of time, a few drops of a carbolic acid solution must be added as a preservative.

MOUNTING.—The operation of adhering the print to a suitable support. Although photographs may be attached to wood, glass, or many other substances, cardboard is the one generally used. The art of mounting only comes by practice. The materials that are required are a suitable cardboard mount and a good mountant. Under the respective headings will be found some information with regard to the selection of these. The prints are first trimmed to size. It is important that they be cut evenly and in proper proportion, as nothing has a worse appearance than a badly cut picture. The mount employed should be of a color and size to suit the picture with regard to its dimensions, to allow of a sufficient margin. The back of the print having been brushed over with the mountant, it is laid very carefully on to the mount, exactly in the center. It is then pressed gently down into perfect even contact with a soft handkerchief, or rolled with a print roller specially devised for the purpose (see Fig. 292), and afterwards rolled or burnished.

FIG. 292.—PRINT ROLLER.

Gelatino-chloride prints which have been glazed by the talced glass process are much more difficult to mount than ordinary albumenized prints. The following remarks by the author* may be found useful.

Gelatine is peculiarly susceptible to moisture, and this, in the case of gelatine prints, where the surface has a high polish, is plainly seen. If we take a piece of dampened paper and lay our glossy print upon it, face upwards, we shall see that this gloss gradually fades away until the surface of the print has become quite dull. Now this effect we have to avoid in mounting gelatine prints. If we simply paste a starch or other similar mountant on to the back, in the same manner as with an albumen print, we lose the polish at once—before, in fact, we have time to attach it to the mount. The more liquid the mountant the stronger its action upon the gelatine film. We will first, then, consider what course to adopt to mounts the prints as they are taken off the glass. If we employ a gelatine mountant with as little water as possible it is evident that we stand less chance of spoiling the surface of the print. Take, then, 1 ounce of hard gelatine and soak it in water; squeeze all the water out of possible, and dissolve. When dissolved, add 4 ounces of methylated spirit. If a large quantity be made, sufficient for some time, a small amount of carbolic acid should be added to prevent putrefaction. This mountant should be placed in small bottles, and when required, a bottle of it should be placed in a little warm water until the contents are dissolved. With a stiff brush it should be rapidly applied to the back of the print, and the latter immediately adjusted to the mount, smoothed down with a soft, clean rag, and the whole laid away, face upwards, to the air to dry. On no account should these prints be laid one on another when mounting, as they will be liable to stick confused together in a heap.

Another way is one that is adopted by a great many amateurs, who treat the edges only of the print to the mounting solution. The same mountant may be used, but with a small brush; it is laid on round the edge of the print in a rim not more than the sixteenth of an inch. It is then attached to the mount. Instead of gelatine, a solution of indiarubber dissolved in benzole may be used, but this adherent is not a stable one. The indiarubber becomes hard after a time and crumbles away, and allows the print and the mount to become detached.

If the method of mounting round the edges be adopted, it should be done directly the picture leaves the glass, as after a little while the print contracts and gives a tight surface. If this be impossible the prints should be removed to a cool damp room or cellar for a few minutes previous to mounting. Gelatine contracts and expands in a very remarkable manner; a very good hygroscope can, in fact, be made out of a piece of gelatine carbon tissue. It is therefore neces-

*The "Camera Magazine," 1890.

sary to avoid mounting the prints by the edges only if in a dry state, as when moist the print contracts and buckles up to those parts not held to the mount by the solution. Another method I must mention, and that is the mounting of these prints behind cut-out mounts. Of course, here we can get the surface as perfect as possible, as no visible portion of the print is treated with the mountant. I think prints mounted in this manner show up a great deal better than by any other way.

We now come to the second *modus operandi*, in which the prints are, before mounting, treated to a support, protective backing, or whatever else you like to call it. When on the glass, and before they are perfectly dry, a piece of thickish waterproof paper is pasted on to the back. A waterproof paper can be obtained at nearly every stationer's; this is usually white one side and coated with a black waterproof substance on the other. Cut this paper for the different prints about one-eighth of an inch each way smaller than the print itself. Apply the mounting solution to the white side, and adhere it firmly to the backs of the prints when on the glass. When dry, the prints, with their waterproof support, will leave the glass together, and they can be mounted with safety with almost any material, as the waterproof coating effectually prevents the damp affecting the gloss. This method of backing is also convenient for prints not to be mounted, as it strengthens them for handling.

If properly done, and the right sort of paper be employed, prints mounted in this manner should not lose a bit of the beauty—vulgar beauty, if you like—of their gloss.

Another method of mounting, which I have purposely left to the last, being the most difficult, is the following. Here we move the prints onto the mount while upon the glass, and strip off together.

The prints, when removed from the water, are squeegeed on to pieces of glass, a little larger only than themselves. When nearly dry, the back is pasted over carefully, and the picture and glass laid on the mount. Of course the print must have been trimmed to proper size before squeegeeing on to the glass. When thoroughly dry the print and mount should leave the glass. If there is any difficulty about this, a sharp knife should be inserted between the print and the glass, to give it a start. It is for this reason that the glass must not be much larger than the print.

Some operators prefer to first damp the cardboard before applying the print, so as to cause it to expand to the same degree as the latter. (See also **Mount and Mountants.**) For special instructions for mounting stereoscopic prints see **Stereoscopic Photographs.**

MUCILAGE.—A term generally applied to various adhesive solutions of gums, dextrine, &c. Chemically it is the gum of seeds and roots, and is obtained by steeping these in hot water, when a thick jelly is obtained. The soluble mucilage may be obtained from linseed by the action of acidulated water on it, and by precipitating the mucilage from a concentrated solution of alcohol.

MULTIPLE COATED PLATE.—A photographic dry plate which has received two or more coatings of sensitive emulsion. This is done to prevent halation, the lower layer of emulsion being a much less sensitive one than the upper.

MULTIPLYING CAMERA.—See **Camera.**

MULTIPLYING LENS.—A faceted lens.

MURIATE OF AMMONIA.—See **Ammonium Chloride.**

MURIATE OF LIME.—See **Calcium Chloride.**

MURIATE OF PLATINUM.—See **Platinum Tetrachloride.**

MURIATIC ACID.—See **Hydrochloric Acid.**

MYRIAGRAMME.—A measure of weight according to the metric system. It is equal to 10 kilos or 22·046 lbs. avoirdupois.

NAPHTHA.—A term applied to the liquid hydrocarbons issuing from the earth in certain parts, and to most of the inflammable liquids produced by the dry distillation of organic substances.

Mineral Naphtha, or petroleum oil, is a complicated mixture of hydrocarbons. It is very inflammable. It does not mix with water, but will impart to that fluid its peculiar taste and smell. It mixes with alcohol and oils. It is used as a solvent for indiarubber, sulphur, phosphorous, camphor, iodine, and most of the resins, wax, fats, etc. It is also employed for illuminating purposes, and for the preparation of a superior lampblack.

Coal Naphtha consists largely of commercial benzole and its homologues; it is extensively used as a solvent of caoutchouc, and also of resins for the manufacture of varnishes.

Wood Naphtha is a name given to impure methylic alcohol. (See **Alcohol.**)

NAPLES YELLOW (Synonym, *Neapolitan yellow*).—An exceedingly permanent orange-yellow pigment, prepared by fusing for two hours at a moderate heat, a mixture of chemically pure antimonia-tartrate of potash, lead nitrate and sodium chloride. On cooling, the fused mass is immersed in water, when the salts dissolve out, leaving the pigment in the form of a fine yellow color. It is much used in oil painting.

NAPHTHALENE (Formula, $C_{10}H_8$; synonyms, *naphthalin*, *naphthaline*).—A frequent product of the dry distillation of organic substances. When quite pure, it consists of brilliant white scaly crystals, very friable, smelling strongly of coal gas, and melting at a temperature of 79 deg. C. to a liquid as clear as water. It boils at 216 deg., and burns when inflamed, with a highly luminous, but smoky flame. It is insoluble in cold and almost insoluble in boiling water, dissolves readily in alcohol, ether, chloroform, carbon disulphide, benzene, and fatty and essential oils. It also dissolves in acetic and oxalic acid.

Naphthalene unites directly with chlorine and bromine, forming a number of substitution products.

It is employed in the preparation of phthalic anhydride.

NAPHTHALINE BLUE.—A blue dye obtained by treating naphthylamine with mercuric nitrate.

NAPHTHALINE RED (Synonym, *Magdala red*).—A very beautiful red dye, prepared from naphthaline by the elimination of three molecules of hydrogen from three molecules of the base $_3C_{10}H_9—_3H_2 = C_{30}H_{21}N_3$ = azo-dinaphthalamine. This, combined with hydrochloric acid, forms the Magdala red of commerce. It is a dark brown, somewhat crystalline, powder, possessing a tinctural power equal to fuchsine, but surpassing it.

NAPHTHYLAMINE (Formula, $C_{10}H_9N$; synonyms, *Naphthalidam*, *Naphthalamine*, *Naphthalidine*).—An organic base prepared from naphthalene. It crystallizes in nearly colorless silky needles, having a most disgusting odor. It is insoluble in water, but soluble in alcohol and ether. Its derivatives and products of decomposition are exceedingly numerous and complicated.

NAPHTHYL CARBAMIDE (Formula, $C_{11}H_{10}N_2O$).—Obtained by saturating an ethereal solution of naphthylamine with cyanic acid gas and recrystallizing from hot alcohol. It forms flat, shining, flexible crystals, insoluble in water, slightly soluble in alcohol, and very soluble in ether.

NARROW ANGLE.—See **Wide Angle.**

NATURAL COLOR PHOTOGRAPHY.—See **Heliochromy.**

NATURALISTIC.—The dictionary meaning of this term is—in accordance with nature. The term has recently been applied to photographs made slightly out of focus. This was first advocated by Sir W. J. Newton, a miniature painter, about the year 1856. Later on, in the year 1874, Dallmeyer constructed a lens specially for this object; by its means the focus of the lens could be diffused by slightly altering the position of the lenses. The latest advocate of so-called Naturalistic Photography is Dr. P. H. Emerson, who has warmly defended it against a storm of deriders. In his work, written on the subject, he says—"The principal object in the picture must be fairly sharp, just as sharp as the eye sees it; but everything else and all other planes of the picture must be subdued, so that the resulting print shall give an impression to the natural scene. But, at the same time, it must be distinctly understood that the 'fussiness' must not be carried to the length of destroying the structure of any object, otherwise it becomes noticeable, and by attracting the eye detracts from the general harmony, and is then just as harmful as excessive sharpness would be. Experience has shown that it is always necessary to throw the principal object slightly (often only just perceptibly) out of focus to obtain a natural appearance, except when there is much moisture in the air, as on a heavy mist-laden gray day, when we found that the principal object (out of doors) may be focused quite sharply, and yet appear natural, for the mist scattering the light softens the contours of all objects. Nothing in nature has a hard outline, but everything is seen against something else, and its outlines fade gently into that something else, often so subtilely, that you cannot quite distinguish where one ends and the other begins. In this mingled decision and indecision, this lost and found, lies all the charm and mystery of Nature. This is what the artist seeks, and what the photographer, as a rule, strenuously avoids."

NEATSFOOT OIL.—An oil obtained from the feet of neat cattle.

NEGATIVE.—The term applied to the image of an object or objects, and in which the lights and shades are reversed. A negative is usually made by direct action of the light on the camera. The image shining upon the sensitive dry plate causes parts to become darkened when subsequently treated with the developer. The lightest parts of the image cause the densest

deposits, so that it will be seen that the image is darkest in those portions which are the lightest in the image itself. Negatives can also be made by printing from a positive.

Negatives are usually made upon glass by the gelatino-bromide (dry plate) or collodion processes, principally the former. Various other supports for the sensitive film have been used. (See **Film Negative Process. Stripping Films. Paper Negatives.**)

A perfect negative is one in which all the gradations or light and shade are correctly and harmoniously rendered. It should be thin and perfectly clear. In some parts of the deepest shadows the glass should be almost clear, while in certain parts of the high lights the film should be almost perfectly opaque. Between these two extremes there should exist as many gradations of tone as possible. If only a few semi-tones are present in the negative, positives made from it will be either weak or hard according to the difference in the opacity of the film in the lights and shadows.

The brilliancy of the negative is dependent upon the correctness of the exposure and subsequent development. If under-exposed, the high lights usually appear black and the shadows perfectly clear without detail, and the gradation of tone between these is, to a great extent, absent. The resulting positives will be hard pictures with masses of black and white without any detail or semi-tones.

If over-exposed, the plate appears too much of the same tint, the shadows appear fogged, the high lights are too light, and the half-tones are almost entirely lost. A positive from such a negative would be too light in the shadows, and too dark in the lights. An over-exposed plate can sometimes be remedied in developing, so that it possesses better printing qualities.

NEGATIVE ABERRATION.—See **Aberration.**

NEGATIVE BATH,—A solution of silver nitrate in distilled water used for the purpose of exciting or sensitizing collodion plates for making negatives by the wet collodion process (*q.v.*).

NEGATIVE BOX.—A box containing grooved sides, which keep the negatives in place and prevents them coming into contact with one another. See Fig. 293.

NEGATIVE CLASP.—An arrangement so as to enable one to remove the negative or plate from the bath without fear of destroying the edges with the fingers. See Fig. 294.

FIG. 293.—NEGATIVE BOX.

FIG. 294.—NEGATIVE CLASP.

NEGATIVE DRYER.—Many attempts have been made to devise a machine by which negatives may be dried in the shortest possible time. The most successful have been those which, by a centrifugal motion, create a strong current of air which takes away the moisture much sooner than by applying heat.

It is not generally understood that the drying of a negative has a great influence upon its character. If it is dried as quickly as possible the result is a pluckier negative richer in contrasts. Most amateurs make the mistake of placing the negative near some heating arrangement, often with the result that the film is softened or melted.

A better method than this is to stand the negative on the window sill with the window open, so as to have a free current of air passing over it. It will dry much sooner. The possibility, however, of the negative falling from the windowsill to the ground below is a decided disadvantage, and if one is located on the twenty-second story of a modern New York building the chances of its reaching the ground without injury are somewhat small.

The most suitable apparatus that we have noted for the studio or for those making a large number of negatives, is the one devised by Mr. F. M Pickard and described in the *Revue Universelle.*

The apparatus consists of a fin with wings, A (Fig. 295), secured at the bottom of a vertical shaft B, given by gears and pinions D, D′, D″, D‴, which are in turn operated by means of a crank, C, or by an electric or water motor, etc.

The plates to be dried to are inserted between two disks, E and E′, loose on the shaft, and which are provided with grooves, H, H, to hold the plates. The upper disk, E′, is adjustable vertically, and can be secured by means of a screw, I, by which the disk may be secured to the shaft B. These vertical rods connect the disks, and serve to secure the coincidence of the groove in the upper disks with those in the lower. Further a grooved flanged disk, M, M′, which may be displaced circumferentially serves to lock the negatives in place.

To operate the apparatus the side, K, is swung back. The upper disk is raised sufficiently to allow the introduction of the negative. The grooves in the disk, M, M′, are then brought to such a position as to secure the negatives. The negatives should be placed with the gelatine side away from the current of air produced by the fan. The side, K, is then closed. If now the thumb-screw, I, is not screwed up, only the fan is set in motion; consequently the air, drawn in at the central opening in the back, will be forced violently against the walls of the cylinder and thrown back back by the cover at the upper end, under a current of air of this strength. The water contained in the gelatine films on the plate will be soon evaporated. When the gelatine is dry on the edges of the plates, the detaching of the film from the plate is impossible, and the thumb-screw, I, may be screwed up, the plates thus being revolved along with the fan, without danger that the film will be disturbed. In a few minutes the plates are dry enough for printing by contact. A gelatine plate, developed and worked for twenty-four hours, may be dried sufficiently for printing by contact in fifteen minutes after being placed in the machine, if allowed to drain for a minute before being placed in the latter. The same machine may be used for drying plates, which have been varnished, or which have been immersed in an orthochromatizing solution

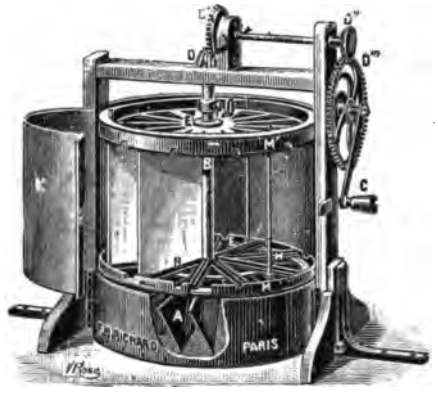


FIG. 295.—F. M. PICKARD'S CERTRIFUGAL NEGATIVE DRYER.

NEGATIVE, ENLARGING.——The crudest and least recommendable method of enlarging a gelatine negative is, to simply soak it in water containing about one-twelfth of its volume of strong liquid ammonia. It two or three hours the film will be found to have frilled from the plate and extended to a considerable extent. If the film is a thick one, the enlargement may be as much as two diameters; but if it is not sufficiently distended, small quantities of hot water should be added to the bath. The loose distended film floating in the bath is then caught upon a large piece of glass. It can, of course, be reversed, if required. This method of enlarging a negative is, however, a very uncertain one, and can only be used with great danger of destroying the negative itself.

The two commonest methods of enlarging negatives are first the production of a positive transparency by contact from the negative and an enlargement made from this; and second an enlarged transparency is made from the small negative, and the large negative made from this by contact. There are plenty of advocates of both methods, but the majority of advantages are probably in the method of producing the enlargement direct from the negative—that is to say, making a large transparency, and printing the negative by contact. In this manner the defects of the positive are not enlarged, and it will be found much easier to eliminate defects on a large than on a small transparency. The large transparency* offers particular facilities for producing one or many enlarged negatives by a printing-out process, as, for instance, on albumenized silver paper after Valentine Blanchard's method. Excellent results can thus be obtained, the sensitive paper is exposed somewhat longer than it would be for a positive print, then washed, fixed, dried and waxed. No toning is necessary, and such paper negatives appear on the whole to be more stable than ordinary toned prints. If necessary, new negatives can easily be made, and each is as exact a reproduction of the first as possible. The various methods of making a transparency are given under that heading.

The negative or transparency to be enlarged must be illuminated equally all over. It will then only be necessary to expose a large plate in the camera to obtain the desired result. Those, however, who do not possess a large camera must enlarge on a dry plate, in just the same way as on bromide or other enlarging paper. The image is thrown by the optical lantern on to the easel, or screen, and focussed. A slight alteration must then be made in this to allow for the thickness of the plate, which is then fixed in position and exposed.

NEGATIVE ENVELOPE.—An envelope in which the negative can be inserted in order to protect its surface.

NEGATIVE NUMBERER.—An arrangement for numbering negatives. The most ingenious form is that devised by Kruse, of Berlin, and which is thus described:—A small benzine light (or candle) is placed in a metal lantern, so constructed both with regard to the admission of light and the letting out of smoke that no white light can escape. On the outside of this box in the right hand corner, there is a groove cut, into which the unnumbered exposed plate is inserted. This slit is covered by three small hoops of thin copper sheeting placed together. Two of these hoops or bands have on them the number oo up to 99, third one has from o to 9. These numbers are cut out like stencil plates, so that by a judicious turning of the bands the numbers ooooo up to 99999 can be seen on looking through the slit. The turning of both these bands, which, num-

* See Chapman Jones's "Science and Practice of Photography."

bered from oo to 99, form the last four figures, is caused by moving a button up or down, by which means the bands referred to are wound off from one small wooden cylinder on to another, whilst the band bearing the numbers o to 9, which indicate the ten thousandths of the number, is changed by every movement of the band from 10 to 10 thousand numbers. In using the instrument the light is shut off by means of a red glass, brought to view from within when looking for the controlling number, the undeveloped plate is inserted in the before-mentioned slit, and then by a sudden turn the red disc is drawn away. The exposure for the number is thereby completed, and the latter appears in the development black upon a bright ground. The apparatus may also be used for printing names, titles, or dates on the negative.

NEGATIVE REPRODUCING.—A negative is generally reproduced by first making a positive by contact, and afterwards a negative or number of negatives from this. For this purpose gelatino-chloride or gelatino-bromide plates may be used. Very fine results can be made by the carbon process. By judicious management the reproduced negative may be made an improvement on the original, that is to say, defects in the former may be remedied or counterbalanced in the latter. In exposing glass under glass, as in this case, it is necessary that absolute contact takes place. Special printing frames have been devised for this purpose.

For methods of producing reversed negatives see **Reversed Negative.** The usual method is through the medium of a transparency. If the dusting-on process is used, however, this will not be necessary.

NEGATIVE VARNISH.—See **Varnish.**

NEOMONOSCOPE.—An instrument for magnifying photographs, invented about the year 1862.

NEPHOGRAPH.—An instrument arranged for the photographing of clouds. It is used at some of the principal meteorological stations and described under **Meteorological Photography** (*q.v.*)

NESSLER'S SOLUTION.—A test for ammonium salts. It is prepared by dissolving sixty grains of potassium iodide in three drachms of distilled water. This is then boiled with successively added quantities of mercuric iodide until some of the latter remain undissolved. This liquid is then diluted with three ounces of distilled water filtered. The filtrate is mixed with 120 grains of caustic potash, dissolved in half an ounce of water, and the whole filtered again.

With this solution the presence of the minutest quantity of ammonia can be detected, as it gives a brownish precipitate or color according to the amount of ammonia present.

Another method of preparing this solution is thus given by Professor Wanklyn. Mercuric chloride in powder, 35 grammes; iodide of potassium, 90 grammes; water, 1¾ litres; heat gently till dissolved (say twenty minutes) in a large basin. Then add of stick caustic potash 320 grammes and 50 c.c. of saturated solution of mercuric chloride. This will be ready for use in two hours, and gives maximum color in three minutes.

This test is as delicate as to be capable of detecting one part of ammonia in ten million parts of water.

NEUTRAL.—This term is used in chemistry to denote that a substance is neither acid or alkaline. It is chiefly applied to compounds of an acid and a base, in which the one has been fully saturated with an equivalent of the other. A neutral compound neither turns red litmus paper blue, or blue litmus paper red.

NEUTRAL SALTS.—Salts which exhibit neither acid nor alkaline properties.

NEUTRAL TINT.—A dull grayish hue, having the character of none of the brilliant colors, such as red, yellow, blue, etc.

A factitious gray pigment used in water-colors. It is composed of blue, red, and yellow, in various proportions.

NEWTON'S RINGS.—Rings of color concentrically arranged, when a very thin lamina of anything transparent is subjected to the action of light.

NICKEL (Symbol Ni; atonic weight, 58·7).—A tetrad metallic element found in combination with arsenic in the copper-colored mineral arsenide of nickel. It is a silver white, malleable, and ductile metal.

NICKEL PLATING.—A method of coating various metal goods with nickel. A dilute solution of pure zinc chloride is first made, and to this is added a solution of nickel sulphate until the liquid is distinctly green. The whole is then raised to a boiling point. The article to be plated is first thoroughly cleaned, and then placed for about thirty minutes in the boiling liquid. The nickel will then deposit itself on the metal, and after washing and drying can be well polished. Another method is to employ a battery as in electroplating.

NICKEL SULPHATE.—(Formula, $NiSO_4 + 7OA_2$.)—A salt of nickel formed by dissolving the carbonate in sulphuric acid. It takes the form of green prismatic crystals, soluble in water. It is used for nickel plating (*q.v.*).

NICOL'S PRISM.—An instrument for polarizing light, named after the inventor. It is formed from a rhombohedron of Iceland spar thrice as long as its diameter. This is bisected in the plane, which passes through the obtuse angle. The new faces, being polished, are cemented together again by Canada balsam. A ray of common light, entering the Nicol prism at one end, is divided into two opposite polarized rays, the ordinary and extraordinary. When these rays meet the Canada balsam cement, the ordinary ray undergoes total reflection from this surface, and is sent out of the field at the side, while the extraordinary ray passes through alone. The emergent ray is therefore polarized in one direction only.

NIÉPCE'S PROCESS, or **NIEPCEOTYPE.**—One of the earliest photographic processes discovered by Niépce. He found that bitumen became insoluble by the action of the light. A metal plate, coated over with a thin film of bitumen (dissolved oil of lavender), was exposed to the image in the camera obscura, and the bitumen became insoluble in proportion to the intensity of the light by which the various parts of the image were produced. This effect is, we know, due to the oxidation and hardening of the resinous substance. After removal from the camera the exposed plate is steeped in a mixture of oil of lavender and petroleum; the soluble portions remaining are dissolved away. The shadows of the image are thus represented by bare portions of the metal plate, the insoluble resin remaining representing the lights and high lights. It will be clear that to get the best effect the polished metal representing the shadows should be darkened. For this purpose Niépce employed iodine and various other chemicals. Niépce, in a statement made in the year 1829, thus describes his process:—"The discovery which I have made, and to which I give the name of 'heliography,' consisting in producing spontaneously by the action of light, with gradations of tints from black to white, the images received by the camera obscura. Light acts chemically upon bodies. It is absorbed, it combines with them and communicates to them new properties. Thus it augments the natural consistency of some of these bodies; it solidifies them even, and renders them more or less insoluble according to the duration of intensity of its action. The substance which has succeeded best with me is asphaltum dissolved in oil of lavender. A tablet of plated silver is to be highly polished, on which a thin coating of the varnish is to be applied with a light roll of soft skin. The plate, when dry, may be immediately submitted to the action of light in the focus of the camera. But, even after having been thus exposed a length of time sufficient for receiving the impressions of external objects, nothing is apparent to show that these impressions exist. The forms of the future picture remain still invisible. The next operation, then, is to disengage the shrouded imagery, and this is accomplished by a solvent, consisting of one part by volume of essential oil of lavender and ten of oil of white petroleum. Into this liquid the exposed tablet is plunged, and the operator, observing it by reflected light, begins to perceive the images of the objects to which it had been exposed gradually unfolding their forms. The plate is then lifted out, allowed to drain, and well washed with water." Niépce further adds, "It were, however, to be desired that by blackening the metal plate we obtain all the gradations of tone from black to white. The substance which I now employ for this purpose is iodine, which possesses the property of evaporating at the ordinary temperature.

NIGHT PHOTOGRAPHY.—Very successful photographs have been made at night time using the illumination from the electric lights. Figs. 296 and 297 are examples made by Mr. W. A. Fraser. This gentleman thus describes his method:

"The first requisite is a strong weather-proof box camera. The one I use for this work is an old style Scovill detective, long ago laid on the shelf, but it struck me when thinking the matter over, that its strength and solidity, made it a very suitable instrument for this purpose, and much work done with it during the past winter has confirmed me in this opinion.

I carry a light folding tripod which can be quickly and easily attached to or detached from the camera, as working in the dark with hands numbed from cold and wet, the simplest operation becomes a task, and the more simple the apparatus, the better the chance of success.

The lens I use is a Ross rapid symmetrical worked at full opening *f*8. Mr. Martin advises the use of a slow orthochromatic plate, but considering the good quality of the fast plates as now made, and the great advantage gained by reducing the time of exposure, an advantage which one will appreciate after a single trial, I very much prefer them, and results do not, in my opinion, suffer in the least from their use.

As halation must be guarded against, I adopted for this work the Seed non-halation plate, and back them as a further precaution.

Working on Mr. Martin's lines I at first included in the

BY W. A. FRASER.

FIG. 296.—NIGHT PHOTOGRAPH.

exposure a minute or two of the last departing daylight, if it might so be called, but my negatives approached too nearly daylight results, and I have since waited until night has really fallen before making the exposure.

Having chosen the view and set up the camera, if the only lights included are gas lamps the exposure with this lens and plate should be from eight to ten minutes, depending somewhat upon the distance to the nearest light, while, if any near electric lights are included, from two and one-half to three and one-half minutes will suffice.

When I speak of electric lights, I refer to those enclosed in opal shades, such as are used on Fifth and upper Madison Avenue in our city. Unprotected lights or those enclosed in plain glass shades I have never attempted, and doubt very much if they can be successfully photographed.

My moonlight pictures were taken between 10 and 11 o'clock, P. M., with moon almost full, and ten mintes' exposure.

During the exposure, a watch must be kept that no vehicle carrying lights crosses the field of view. My practice is to stand beside the camera, keeping one hand firmly on it, if it is blowing hard, several exposures I found were ruined through movement of the camera caused by the strong wind, then when a cab or other vehicle carrying a light enters the field of view, I, with the other hand, cover the lens until it has passed.

Moving objects not bearing lights make no impression on the plate.

In the development I aim at softness, and use a rather weak metol developer, two ounces stock solution diluted with water to four ounces, and with very little, say two drachms, alkali, no bromide.

BY W. A. FRASER.

FIG. 297 —NIGHT PHOTOGRAPH.

The amount of detail picked up by the lens when using this plate, has been a constant source of wonder to me ; in every case, very much more than my eye could see was disclosed when the plate had been developed and fixed.

I prefer a stormy night for this work, either snow or rain, as the artistic effect is unquestionably much greater on these occasions."

NITRATE OF AMMONIUM.—See **Ammonium Nitrate.**

NITRATE OF BARYTA.—See **Barium Nitrate.**

NITRATE OF CELLULOSE.—See **Pyroxyline.**

NITRATE OF IRON.—See **Ferrous Nitrate.**

NITRATE OF SILVER.—See **Silver Nitrate.**

NITRATE OF STRONTIUM.—See **Strontium Nitrate.**

NITRATES.—Combinations of nitric acid with bases. For the most part they crystallize readily; they are all soluble in water, and are generally neutral to test paper. The tests for nitrates are as follows :

Solid nitrates, heated with copper and strong sulphuric acid, liberate red fumes. Liquids containing nitrates give the following reactions. Treated with an equal volume of strong sulphuric acid and allowed to cool, and then mixed with a fleshly prepared and clear solution of ferrous sulphate carefully added so as to float on the top, a brown ring will be observed at the junction of the two liquids.

If mixed with a little strong sulphuric acid, and then added to solid brucine, a red solution is produced.

NITRE.—A name applied sometimes to potassium nitrate and sometimes to sodium nitrate; more frequently to the latter, however, the former being especially distinguished as saltpetre.

NITRIC ACID (Formula, HNO_3; molecular weight, 63; synonym, *aqua fortis*). A heavy, colorless liquid prepared by the action of strong sulphuric acid upon potassium or sodium nitrate. The strongest obtainable possesses a specific gravity of about 1.5, but a large proportion of what is now sold as nitric acid contains often as much as from 40 to 50 per cent of water.

It is very easily decomposed, giving off fumes when exposed to the air. Mixed with about four times its volume of hydrochloric acid it forms *aqua regia*, which possesses the property of dissolving gold and platinum.

The following table gives the strength at different sp. g.

SPEC. GRAVITY AT 15°C.	PERCENTAGE OF REAL ACID.	SPEC. GRAVITY AT 15°C.	PERCENTAGE OF REAL ACID.
1.530	100.0	1.251	40.0
1.495	90.0	1.185	30.0
1.460	80.0	1.120	20 0
1.423	70.0	1.089	15.0
1.374	60.0	1.060	10.0
1.317	50.0	1.029	5.0

Nitric acid acts upon the majority of the inferior metals, and their hydrates or carbonates, producing nitrates. It also acts upon silver and upon various forms of cellulose, such as cotton-wool, paper, &c., its action being the same as with the metals. Cotton-wool acted upon by nitric acid forms gun cotton or pyroxyline, which is in reality a nitrate of cellulose, or a mixture of cellulose nitrates.

Nitric acid has a very sharp, penetrating, and obnoxious odor somewhat resembling hydrochloric acid. It is very poisonous, and has a most powerful corrosive action. Commercial samples sometimes contain traces of hydrochloric acid. For many purposes, for instance in the preparation of silver nitrate, it must be entirely free from this acid. The presence of hydrochloric acid can easily be detected by dropping into a test tube containing some of it a few drops of a silver nitrate solution. If any be present it will combine with the silver to form chloride of silver, and the whole will become turbid. Its uses in photography are chiefly in the manufacture of silver nitrate and pyroxyline; for the latter purpose it must have a specific gravity of at least 1.4. Nitric acid stains can be removed from the hands or clothes by touching with a solution of potassium permanganate, wash well in dilute hydrochloric acid and then in water.

NITRITES.—The salts of nitrous acid. If solid nitrites be warmed with dilute hydrochloric acid, brownish red fumes will be yielded. Liquids containing them give a white precipitate with silver nitrate, and a brown or black coloration with ferrous sulphate.

NITRO BENZENE (Formula, $C_6H_5NO_2$; synonym, *nitro-benzol*).—A heavy, oily liquid prepared by gradually adding benzene to cold fuming nitric acid so long as it dissolves, and precipitating with water. It possesses a strong almond-like odor, is insoluble in water, but soluble in alcohol and ether. It is largely employed in the preparation of aniline and its derivatives.

NITRO-CELLULOSE.—See **Pyroxyline.**

NITROGEN (symbol, N; atomic weight, = 14).—A pentad metallic element forming four-fifths of the atmosphere, and entering into a great variety of combinations. It is generally procured from the atmosphere by burning a piece of phosphorous under a bell jar standing over water. The phosphorus unites with the oxygen, forming phosphoric acid, which is readily soluble in water, leaving the nitrogen behind. There are various other ways of obtaining it.

Nitrogen is colorless and without taste or odor. It is incombustible, and does not support respiration; it is not poisonous, but kills from the absence of oxygen. Its action on the atmosphere is chiefly as a diluent to moderate the activity of the oxygen. It has recently been liquefied by the aid of cold and high pressure.

NITROGEN IODIDE (Formula, NHI_2) can be prepared by dissolving iodine in a mixture of hydrochloric with a little nitric acid, with the aid of heat, and adding ammonia, which decomposes the ICI in solution, and gives a black precipitate of the iodide of nitrogen *

Nitrogen iodide is a black powder, exploding with a loud report, even if touched with a feather.

It decomposes by the aid of light, and has been recommended as a means of comparing light intensities by its decomposition. Two vessels, with glass bottoms, are placed side to side, being of equal size. Iodine and ammonia solutions are placed in each, forming the iodide of nitrogen, which remains unaltered so long as it is in the dark. The two lights to be compared shine by means of a mirror, each into one of the vessels. The amount of nitrogen gas given off each is is collected in a tube above in ammonia water, and the relative height shows the relative activity set up by the light. Precautions have to be taken to avoid effects of heat.

NITROGEN TRIOXIDE.—See **Nitrous Anhydride.**

NITRO HYDROCHLORIC ACID.—More commonly known as *aqua regia*. A mechanical mixture of one part of nitric acid with about four times its volume of hydrochloric acid. It has

*Bloxham's "Chemistry."

the property of dissolving gold and platinum, the active agent being the chlorine liberated from the hydrochloric acid by the oxygen of the nitric acid, thus—

$$O+2HCl=H_2O+Cl_2$$

It is used for the purpose of dissolving gold in the preparation of gold perchloride, much used in photography for toning purposes.

NITROUS ACID. - See **Nitrous Anhydride.**

NITROUS ANHYDRIDE (Formula, N_2O_3; synonyms, *nitrous acid, nitrogen trioxide, anhydrous nitrous acid*).—Prepared by mixing four volumes of nitric oxide with one volume of oxygen, and exposing to a temperature of — 17 deg. It condenses to a thin green liquid, its vapor being orange red. It is decomposed by water into nitric acid and nitric oxide.

NOBLE METALS.—A term applied to the metals gold, silver, platinum, osmium, rhodium, iridium, and mercury. These can be separated from oxygen by heat alone.

NOMENCLATURE, PHOTOGRAPHIC.—The nomenclature of the various photographic inventions and processes seems to have been carried out without the slightest regard to law or order. The most absurd and meaningless words have been adopted, and which are in many cases liable to lead the student astray.

At an International Photographic Congress held in Paris in 1890 the following rules were laid down as a basis for a system of rational nomenclature* :

1. The expression *photo* shall be employed to the exclusion of the word *helio* to indicate processes due to the action of light from any source whatever, and not alone to the action of solar light. The expression *helio* is exclusively reserved to indicate those processes only in which solar light is used.

2. The expressions *positives* and *negatives* are reversed to indicate respectively the images in which the effects of light and shade resemble those of nature, or in which those effects are reversed.

3. In that which concerns *photographs* obtained solely by the chemical action of light, the name of *phototypes* will distinguish those produced directly by the use of the camera. The name *photo-copies* will be given to the reproductions of these by a new photographic operation by means of a sensitive surface acted upon by light.

The name *photo-calques* (photo-sketches?) will be given to reproductions made in the same way from non-photographic original designs.

4. Photo-mechanical prints, or *phototirages*, which may also be called *photo prints*, will be differentiated by the following appellations :—

To designate these different processes, an insertion will be made between the two radicals which form the word *photography*, and which will indicate the principal characteristic of the particular process.

According to this rule the word *photo-collography* will indicate reproductions in various inks by processes in which colloids (gelatine, albumen, bitumen and so on) are spread upon various supports, and rendered fit for inking by the action of light.

The word *photo plastography* will be employed to indicate processes in which a plastic substance changes its form because of the action of light, and returns to a thickness suitable for a colored gelatinous ink.

The word *photo-glyptography* will be used for processes of engraving in intaglio by photography.

The word *photo-typography* will be employed for photographic processes of engraving in relief for use in the type-high letter printing press.

The word *photo-chromography* will be applied to printing processes for the reproduction of photographic images of several colors.

5. More extended designations of photographic processes or operations may be applied, so far as the French language is concerned, by introducing generic words preceding the necessary indications of the nature of the processes or operations.

For instance, the preposition or *à par* (by), according to the case, will precede the words indicating sensitized substance employed, or that of the mode of operation ; and the preposition *upon* precede the words indicating the nature of the support of the preparations. The names of the inventors, if they have to be used, can be placed at the end.

EXAMPLES.—*Photographs.*—1. Positive photo-type ; iodide of silver on a metallic plate (Daguerre's process). 2. Positive photo-type ; collodion on a metallic plate (Ad. Martin's process). 3. Negative photo-type ; collodidio-bromide of silver on glass. 4. Positive photo-copy ; gelatino-chloride of silver on paper. 5. Positive photo-copy, in mixed colors (Poitevin's process). 6. Negative photo-sketch ; ferro prussiate blue paper (Motileff's process). 7. Positive photo-sketch ; gallate of iron. *Photo-prints.*—8. Photo-collography ; bichromated gelatine on ground glass 9. *Photo-plastography* ; colored gelatinous inks (Woodbury's process). 10. Photo-glyptog-

*Photographic News, Feb. 21, 1890.

raphy, by bitumen of Judea on steel (Niépce's process). 11. Photo-typography, by bitumen of Judea on zinc.

6. For the designation of the divers applications of photography to especial purposes, are reserved several compound words, obtained by prefacing the photography with radicals indicating by abbreviation the particular applications

EXAMPLES:—Chromo-photography, the photographic production of successive images taken at accurately measured intervals of time. Micro-photography, the photography of microscopic objects. Helio-photography, the photography of the solar surface. Spectro-photography, the photography of the spectra given by luminous sources. Urano-photography, the photography of celestial spaces. Chromo-photograhy, the direct obtaining of the reproduction of colors by photography.

NON-ACHROMATIC LENS.—A lens not corrected for chromatic aberration. (*q.v.*).

NON-ACTINIC.—Applied in photography to rays of light which have comparatively no action upon sensitive substances. These rays are chiefly in the yellow and red ends of the spectrum. Light passing through red or yellow glass, paper, or other media, has no effect upon sensitive photographic material, unless of long exposure; it is therefore employed to enable the operator to perform the various operations that are necessary in the development of the image, etc. In photographing a landscape or colored objects it is obvious that the yellow and red portions will have but little effect, and appear in the finished print as back parts, although they may appear somewhat bright to the eye. This defect in photography has been partially overcome in the orthochromatic process (*q.v.*).

NON-ACTINIC MEDIA.—Media for the transmission of non-actinic rays of light. The color of this depends greatly upon the nature and sensibility of the material to be handled. It varies from a deep ruby to a pale orange. Abney recommends bookbinders' red cloth combined with stained red glass. It should be noted that ruby glass by itself will rarely be found sufficient, since a certain amount of blue light is apt to permeate it.

Many advocates have been found for a paper treated with lead chromate, and termed canary medium. For developing ordinary plates two thicknesses of this substance will be found sufficient. There is, however, an orange paper which will be found useful, as it retards more of the green rays.

It is well to note that if a plate be first exposed to white light and afterwards to red, a reversing action will occasionally take place, the image eventually disappearing. It is, therefore, necessary to avoid handling the exposed plate in the red light as much as possible until commencement of development.

The value of the light coming through stained, red, and ruby glass, orange paper, the canary medium will be seen on reference to Fig. 298.

Spectroscopic tests recently made have shown that few of the commercial so-called "non-actinic" glasses are as safe as could be desired. Vogel suggests that ruby glass so difficult to obtain should be replaced by

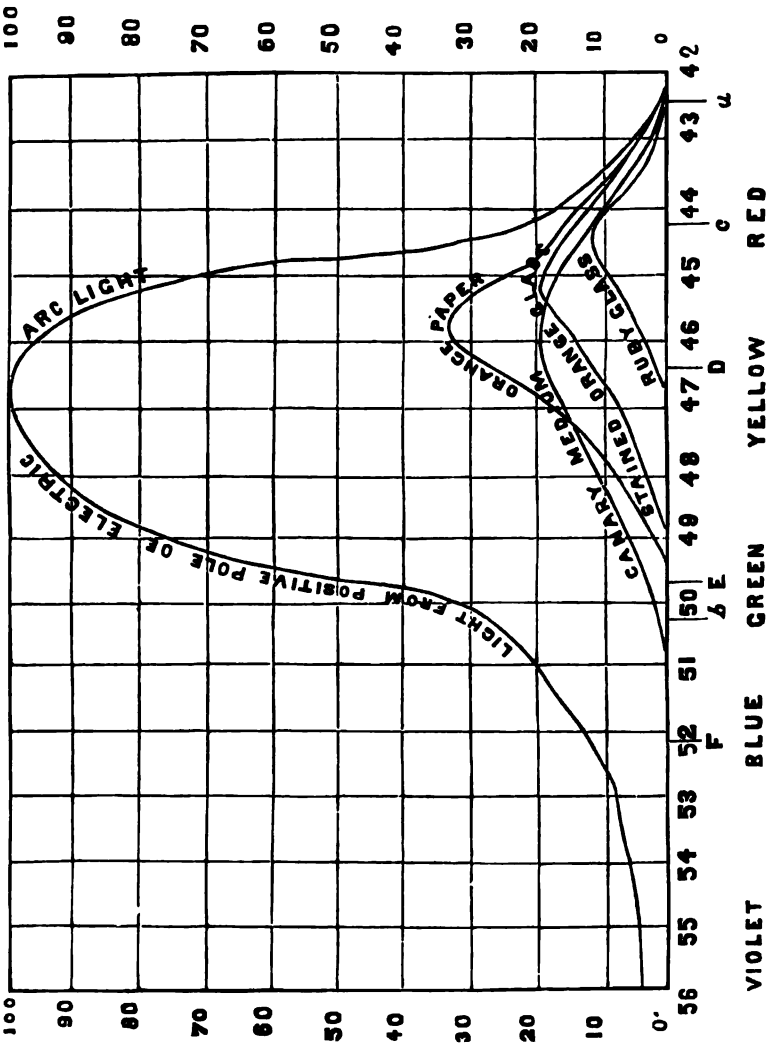


FIG. 298.

colored gelatine films. His method of manufacturing these is as follows :—1 gramme of aurantia is dissolved by aid of heat in 100 c.c. of distilled water. Unless the whole of the aurantia dissolves, a few drops of ammonia should be added. 20 grammes of gelatine are also dissolved in 100 c.c. of water. 25 c.c. of the aurantia solution are taken and mixed with 25 c.c. of the gelatine solution, and the mixture filtered through flannel. With this solution leveled glass plates are coated. These plates absorb the blue rays only, and are therefore only suitable for use in developing wet collodion or low sensitive gelatine emulsion plates or paper, as they allow the yellow, green, and red rays to pass through freely. For development of highly sensitive plates rhodamine should be used, as a concentrated solution of it absorbs yellow, green and violet completely, whilst blue and red light pass through freely. 8 grammes of rhodamine are dissolved in 250 c c. of water, and 20 grammes of gelatine in 100 c.c. of water. 25 c.c. of the gelatine solution are then mixed with 30 c.c. of the rhodamine solution, and the mixture filtered. If we combine a glass plate coated with this solution with one made with aurantia as previously described, we get a perfect nonactinic medium, permitting only red light to pass through. The two plates when dry are fixed together, film to film. If, previous to coating the glass plates, they had been rubbed over with French chalk and then provided with a substratum of collodion, the films could be stripped from the glass when dry, and used for dark room lamps, etc.

NON-REVERSING SLIDE.—A camera slide, so contrived that collodionized glass plates may be exposed in it with the back of the plate next the lens, and the film next to the back shutter.

NOTATION, CHEMICAL.—The written language of chemistry. The system now used belongs exclusively to modern times, although in all ages signs of some kind or other seem to have been employed to represent the various kinds of substances. (See **Chemistry.**)

OBERNETTER PAPER.—A gelatino-citro-chloride of silver printing-out Aristotype paper. (See **Gelatino-chloride of Silver Process.**)

A suitable toning bath for Obernetter papers is the following :

Ammonium sulphocyanide	140 grains
Sodium phosphate	140 grains
Sodium tungstate	100 grains
Water	24 ounces

Dissolve, and place some scraps of sensitized paper, spoiled prints (untoned), etc., in the bottle, and allow it to stand for about 24 hours. Filter and then add :

Gold terchloride	15 grains
Water	4 ounces

Examine during toning by transmitted light, and tone to a rich purple brown.

Fixing is accomplished with one part of hypo in ten of water. After well washing they are hung up to dry, or squeegeed on to the talced glass.

OBERNETTER'S PROCESS.—A photo-engraving process known in Germany as Lichtkupferdruck. A positive is first produced on a film of gelatino-bromide of silver, very rich in the silver salt. The silver of the developed and fixed image is then converted into silver chloride by the action of a mixture of perchloride of iron and chromic acid. The film is then stripped and laid on the surface of a copperplate. Under the influence of a voltaic current, the silver chloride becomes decomposed, and the chlorine unites with the copper and etches it to a greater or less degree, according to the depth of deposit of silver chloride. As a result a grained intaglio plate of great delicacy is obtained. This is inked and printed from in the same manner as an ordinary etching.

OBJECT FINDER.—A device used in connection with the mechanical stage to mark the position in the field of view of a microscope. (See also **Finder.**)

OBJECT GLASS.—The glass placed next to the object in a telescope or microscope is termed the object glass. In good instruments this is usually composed of two or more lenses cemented together, one being of flint glass, and the other or others of crown glass.

OBJECTIVE.—A lens or combination of lenses used in the telescope, microscope, or photographic camera, and by which the image-forming rays are first received.

OBSCURE RAYS.—Invisible rays above and below those of the visible spectrum. (See **Spectrum.**)

OIL.—The term oil is generally applied to all neutral fatty substances which are liquid at ordinary temperatures. They may be divided into two great classes,* fixed oils and essential oils.

* Rodwell's "Directory of Science."

Fixed Oils.			Essential Oils		
Drying.	*Non-Drying.*	*Non-Drying.*	*Drying.*	*Non-Drying.*	*Non-Dryiug.*
Linseed Oil.	Almond oil.	Earth-nut oil.	Oil of anise.	Oil of cloves.	Oil of nutmeg.
Poppy oil.	Beech-nut oil.	Oil of mustard.	Oil of bergamot.	Oil of lavender.	Oil of orange peel.
Sunflower oil.	Castor oil.	Rape seed oil.	Cajeput oil.	Oil of lemon.	Oil of peppermint.
Walnut oil.	Cotton seed oil.	Sesame oil.	Oil of carraway.	Oil of mint.	Oil of rose.
Tobacco seed oil.	Colza oil.	Olive oil.	Oil of cassia.	Oil of myrrh.	Oil of thyme.
Cress seed oil.			Oil of cedar.	Oil of neroli.	Oil of turpentine.

Oils are inflammable either at the ordinary temperature or when heated. The fixed oils are not volatile without decomposition. Some of them oxidize when exposed to the air, and dry to a caoutchouc-like substance. The essential oils are of a peculiar pungent odor, distill without decomposition, and are very inflammable.

OIL COLORING.—Photographs may be colored in oils if first coated with japanner's quick gold size. The following excellent instructions for tinting in oils are given by a correspondent in *Photography** :—"For tinting pictures in oil the following colors will be required: White, Naples-yellow, yellow orchre, raw sienna, burnt sienna, mars orange, light red, vermillion, pink madder, crimson lake, Indian red, raw umber, burnt umber, terra verte, emerald green, ultramarine, Prussian blue, ivory black, and whatever other colors the particular draperies and background may require. Payne's gray is also useful. Use sufficient megilp to render the colors thin and transparent, and lay the colors on with as little disturbance as possible to secure their purity. Commence by carrying a warm tint of light red and burnt umber over the darkest shadows; use white, terra verte and Indian red for the lighter shadows, white and terra verte for blending the high lights. The following are the best combinations for various complexions: White, Naples-yellow, and vermillion; the same, with an addition of light red, white and pink madder, with a little vermillion for the tint on cheek. If these colors are mixed in small quantities those most suitable for the model can be easily selected. The shadows may be glazed over with a mixture of white, light red, and emerald green, or white, Indian red, ultramarine, and raw umber, the complexion of the person indicating the choice. The high lights should be touched in with white and Naples-yellow graduating into the local color. Strengthen the nostrils and the lines of the eyelids, and that separating the lips with Indian red. Carry a line of brown or indigo, as may be required round the iris of the eye, put in the local tint, the reflected light and the pupil, remembering the part of the eye called white is really grayish, more or less light, according to the position of the eyes and length of eyelashes. The eyebrows and hair should be glazed with a suitable brown, keeping the former soft, transparent, and hairlike, and the divisions of the hair well but not too strongly defined, and the hair transparent where it meets the brow. The high lights of the hair will be bluish, being colder by contrast as the hair is dark or fair. Use Payne's gray mixed with shadow tints to blend the hair and face. Black dresses or coats should be glazed with a warm transparent black, into which strengthen the lights with tints of black and white mixed, and deepen the shadows with Vandyke brown and a little lake. Should the hands require painting they should be done with the same tint as face, with the addition of a rosy tinge on the knuckles and tips of fingers, and the divisions strengthened with a warm shadow tint. All draperies may be done as in case of black with such colors as the fabric may require, remembering always where the lights are cold the shadows must be warm. For lace or linen use white and blue-black, white, black, and burnt umber, with white for the lights. For gold ornaments use yellow ochre or Naples-yellow, yellow ochre and raw umber, and burnt sienna and raw umber."

OILED NEGATIVES.—Negatives made upon paper used as a substitute for glass are usually oiled or otherwise treated to render them more translucent, and consequently to print with greater rapidity Oiled negatives require to be kept in oiled or waxed paper. (See **Paper Negatives** and **Translucent.**)

OILED PAPER.—Paper treated with oil. (See **Translucent.**) A paper of this kind is often useful for photographic purposes—for instance, where an air-proof packing is required. Oiled-paper negatives should be kept in oiled or waxed paper.

OIL OF SPIKE.—A volatile oil obtained by distilling the leaves and stalks of the lavender. It is not so agreeable as lavender oil (*q.v.*), is specifically heavier, and deposits a large quantity of camphor.

It is used in the manufacture of encaustic paste, varnishes, etc. (See **Lavender Oil.**)

OIL OF VITRIOL.—See **Sulphuric Acid.**

* March 6th, 1890.

OIL PAINTINGS, PHOTOGRAPHING.—The photographing of oil paintings was formerly beset with difficulties owing to the incorrect relation of the photograph to the colors, that is to say, a light yellow on a dark blue ground would appear in the photograph in the opposite to what is apparent to the eye. This defect has been considerably overcome by the use of the orthochromatic process.

The oil painting should be well lighted, and a slow and thickly coated plate used. For method of orthochromatizing the plate, see **Orthochromatic Photography.**

OLIVE OIL.—A non-drying oil extracted from the fruit of the olive. It has a pale yellow color, with a mild agreeable taste. It solidifies between 0° and 10°.

OPAL.—This term is applied to pictures made upon opal glass by various processes. Opal plates coated with gelatino-chloride or gelatino-bromide emulsion are now largely manufactured, and sold ready for use. These are exposed behind the negative, and developed in the ordinary manner. Pictures upon opal glass can also be produced by the powder or dusting-on process, and by the carbon or Woodbury printing methods. See **Opalotype.**

OPAL GLASS is made by fusing one of the oxides of tin or zinc with the metal. It is sold for photographic purposes in two different states, *i.e.*, "plain" and "smoothed," the former possessing the natural polished surface of the glass, and the latter being very finely ground. The latter is more generally employed, owing to the softer effect given to the picture, and also to the difficulty in obtaining even pieces of the polished kind.

Flashed opal is made by laying a thin veneer of the opal glass on to a greater thickness of clear glass.

OPALINE.—This is a name given to prints mounted in optical contact with a piece of clear beveled glass. In this manner they possess somewhat the appearance of a picture upon opal glass. The prints should, if possible, be vignetted, so as to leave a white margin all round the edge of the glass. The method of mounting them in optical contact is the following: After toning, fixing, and washing, the pictures are dried between blotting boards placed under pressure. Soak about two ounces of soluble gelatine in cold water until soft, then add sufficient boiling water to make a rather thick solution. When the gelatine is thoroughly dissolved, filter it through muslin into a clean glass or porcelain dish standing in a hot water bath, the temperature of the solution to be kept at about 100 deg. F. Have the beveled-edged glasses perfectly clean and near at hand. Immerse a print in the gelatine, and when soaked lift it out and lay it quickly on the glass, and at once firmly squeegee it.

When dry the print is trimmed with a sharp knife to the exact size of the glass on which it is mounted. A piece of leatherette paper can be pasted on to the back to give a better finish.

OPALOTYPE.—A term applied to pictures made upon opal glass. The simplest method of producing them is upon opal glass, coated with a gelatino-chloride or gelatino-bromide emulsion. Either polished or ground opal may be used; the latter gives very artistic matt pictures. These plates are exposed under the negative, they are then soaked in water for a few minutes, and then developed with a ferrous oxalate, eikonogen or hydroquinone developer. They are then cleared and fixed. In warm weather an alum bath should be used.

Another method is to coat opal plates with a gelatino-chloride printing-out emulsion, and then print out, tone, and fix, as with gelatino-chloride paper.

A common method of producing these pictures is with a collodio-chloride emulsion, made up according to the following formulæ:

SOLUTION 1.

Silver nitrate	15 grains
Methylated alcohol	14 drachms

Dissolved by slightly warming.

SOLUTION 2.

Strontium chloride	15 grains
Methylated alcohol	14 drachms

SOLUTION 3.

Citric acid	15 grains
Methylated alcohol	14 drachms

SOLUTION 4.

Pyroxyline	31 grains
Methylated alcohol	14 drachms
Methylated ether	14 drachms

To prepare the emulsion, 150 minims of No. 2 are added to the same quantity of No. 3; 28 drachms of No. 4 are then added. Mix up well together, then add very slowly 75 minims of No. 1, stirring the whole up while the addition is being made.

The plates are first treated either over the whole or the edges only with albumen or india-rubber solution, and after coating with the collodion are allowed to become thoroughly dry. These plates are then printed upon, toned, and fixed as with albumen paper. Special printing frames have been devised to enable the operator to examine the opal during the process of the printing operation. (See **Printing Frame.**)

OPAQUE.—Bodies are said to be opaque when they are impervious to rays of light. No body is, however, absolutely opaque, as when reduced to sufficiently thin laminæ they always transmit a portion of the light which strikes them.

OPERA GLASS CAMERA.—A camera made in the form of an opera glass.

OPTICAL AXIS.—See **See Principal Axis.**

OPTICAL CENTER.—Every lens possesses a certain point, situated on its principal axis, termed the optical center. At this point every incident ray which passes through it does not undergo deviation, but pursues a path parallel to its original course.

Only single lenses have perfectly true optical centers in an achromatic combination; its position may be ascertained approximately by considering it as a single lens.

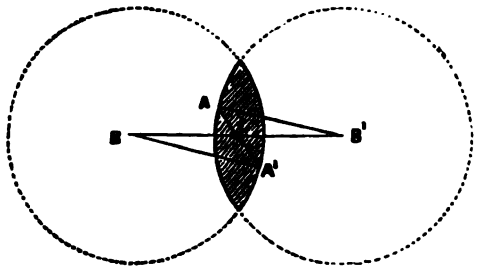


FIG. 290.

In order to obtain the optical center of a single lens, first draw a line B C B′ (Fig. 290). This to represent the principal axis. From the centers of curvatures B B′ next draw two radii B′A and B A′ parallel to each other, but oblique to the central axis B B′. Next join their extremities A A′, and the point C where this line cuts the principal axis is the optical center. To obtain the optical center of a meniscus lens, prolong the line AA′ to the point where it meets the principal axis, and this will be the optical center. In plano-convex and plano-concave lenses it is found by the inter-section of the spherical surfaces of the axis. The optical center of a plano-convex lens is on the convex surface, and of a plano-concave on the concave surface. If the lens be a meniscus or a concavo-convex, it will be outside the lens altogether, and its distance from the two surfaces will differ in proportion as their radii of curvature differ. The point C (Figs. 300 and 301) shows the position more clearly of the optical center of a plano-convex and a meniscus. Another method of finding the optical center of the lens is the following:

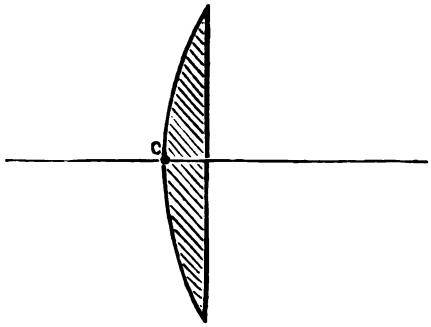


FIG. 300.

Let r be the radius of the front surface of a lens, s the radius of the back surface, and t the thickness of the lens, then the distance of the optical center, measured along the axis of the lens from the center of the face of the front surface, is equal to $\frac{rt}{s-r}$

By giving to r and s the proper algebraical sign and a given magnitude, the position of the optical center of any lens may be easily found.

OPTICAL CONTACT.—A photograph is said to be mounted in optical contact when it is so firmly attached to a piece of glass that no intervening air is perceptible. (For method of mounting prints in optical contact see **Opalines.**)

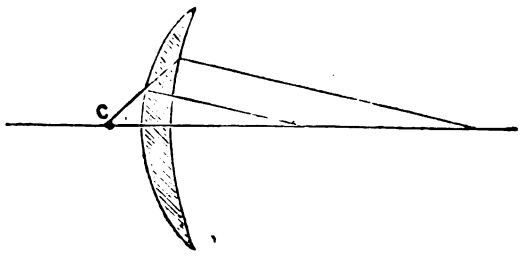


FIG. 301.

OPTICAL INSTRUMENTS, PRESERVING.—All optical instruments, if required to be kept in good working order, should be carefully preserved from light and moisture, which have a peculiarly ruinous effect upon the glass. Lenses, when not required for use, should be kept in small chamois leather bags made to fit. If the brasswork of the lens become scratched and dirty, it may be carefully cleaned, polished, and relacquered. The lenses should be removed carefully, noting their position to avoid error in resetting, and the old lacquer removed with a rag dipped in methylated spirit. The brasswork is then polished with a piece of fine emery cloth, the rubbing of the cloth being done in one direction only. After sufficient polish has been obtained, a small quantity of a lacquer is poured into a saucer or egg-cup. This lacquer is composed of—

Seed lac	12 ounces
Copal	4 ounces
Dragon's blood	80 grains

Extract of red sanderswood	50 grains
Saffron	70 grains
Pounded glass	½ pound
Spirits of wine	2 quarts

A fine flat camel-hair brush is the most suitable instrument for lacquering. The article is first warmed to a gentle heat, and the lacquer applied with the brush in one direction only, if possible. It will sometimes be convenient to hold the article by a piece of wire fitted into some hole in it. It should not be heated to more than about 200 deg. Fahr. The principal points in lacquering are to keep the brush clean, and charged with as little of the solution as possible. The brasswork must also be quite clean, and not made too hot. Another lacquer, somewhat simpler to that already given, can be made by dissolving one half pound of the best pale shellac in one gallon of methylated spirit, and filtering. Yellow tints may be given to it by the addition of saffron or gamboge, or, if a redder color is required, annatto or dragon's blood should be added.

The inside of the lens mounts may be re-blackened by applying this lacquer in the same manner, the solution having been previously mixed with finely triturated lampblack. Only one or two coats should be given, or its surface will become glossy, and it is obvious that this is to be avoided.

OPTICAL GLASS.—Glass specially manufactured for the construction of photographic lenses. This is usually crown or flint. Patents have been taken out by Drs. Abbe and Rudolph, of Jena, for the manufacture of a new glass for lens-making. This new Jena glass, as it is called, has now been placed on the market, but lenses have already been made of it by English as well as foreign opticians. Messrs. Swift and Son have manufactured a lens of Jena glass which has an angular aperture so great that it can be used for portrait work even in a badly-lighted room, its full aperture being *f*/4. It has an equivalent focus of 4½ inches, and is fitted with an Iris diaphragm. Wray has also manufactured a lens of this kind of glass with an Iris diaphragm, extending from *f*/8 to *f*/64. A lens which covers a quarter-plate with ease with full aperture will cover an 8½ x 6½ plate with the diaphragm contracted. (See under **Glass.**)

OPTICAL LANTERN.—An apparatus employed for projecting magnified images upon a white screen. The rays emanating from an artificial source of light are collected together and passed through a transparent positive picture, which by the divergence of the rays through a lens is thrown brilliantly illuminated and magnified on a screen. The practical requirements in an optical lantern are first a light-tight box or case containing the illuminant, a lens or condenser to concentrate the light and throw the rays evenly and uniformly through the transparent slide, and a lens for magnifying the image. If an oil lamp be used a silver reflector will also be necessary. A large variety of lanterns are now manufactured.

The Illuminant.—The cheapest form is the ordinary colza or sperm oil lantern. Paraffin oil is now generally used, burnt with a combination of from two to five wicks. This is usually accomplished by placing the long wicks parallel with or sloping towards each other, so that by a proper regulation of the ventilator the flames are made to converge and unite in one brilliant light.*

The accompanying illustration depicts a very convenient form of oil lantern.†

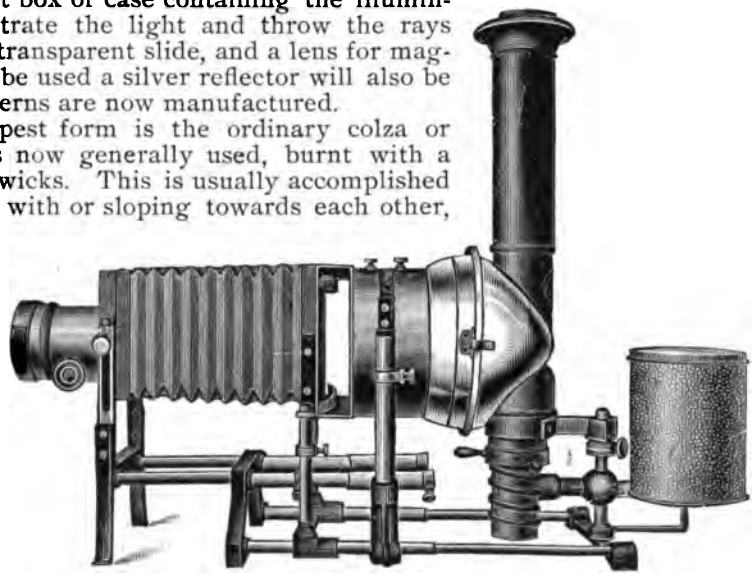


FIG 302.—OPTICAL LANTERN WITH OIL ILLUMINANT.

It will be noticed that by an ingenious arrangement the oil reservoir is kept as far from the flame and heat as possible, thus doing away with the obnoxious smells so prevalent with this form of lantern.

The limelight is the illuminant most generally in use. There are four different systems, *i.e.*—(1) the oxycalcium or spirit jet; (2) the blow through; (3) the mixed; (4) the ether-oxygen light. All these depend for their illuminating qualities on the incandescence of a cake of lime by the impact upon its surface of a jet of oxygen passed through or mixed with a hydrogen or other flame to maintain combustion, because oxygen alone will not maintain a flame.

The limelight was first discovered about the year 1826, by Lieut. Drummond, R.E., but the modern methods of construction differ considerably.‡

The best limes to be obtained are of the kind known as "hard" or Nottingham limes.

* The Indispensable Handbook of the Optical Lantern.—Iliffe & Son. † Manufactured by J. B. Colt & Co.
‡ The Book of the Lantern, by T. C. Hepworth.

For all these four systems of limelight, the manufacture of oxygen is necessary. This will be found treated upon under **Oxygen** (*q.v.*) It can now be purchased ready made in almost every town in strong steel cylinders. The oxycalcium or spirit jet requires spirits of wine as the flame maintainer, a reservoir containing spirits being attached to the jet in such a manner as to keep up a constant supply of spirit in a small lamp placed in front of the lime support. The spirit lamp is first lit, and then the oxygen turned on and is thrown by the jet through the spirit flame on to the lime, which it lights up with extreme brillance.

The blow-through or safety is similar in its action to the oxycalcium, except that instead of the spirit lamp the flame of a jet of hydrogen is used. This is the most commonly used form of lime jet. If properly constructed it should illuminate a picture at least 15 feet in diameter. The hydrogen gas can be supplied from the nearest household source by means of an indiarubber tube. It is carried to a point just in front of the lime, and the oxygen tube is carried out in front of it and brought round to an angle so as to cross the lines of flame and blow the oxygen through the hydrogen flame as it emerges from the nozzle. This system is a perfectly safe one. The others are all attended with more or less danger. It must be remembered that hydrogen and oxygen when mixed together form an explosive vapor of enormous power. In the safety jet, there is absolutely no danger of explosion, for the reason that no mixture of the gases takes place until they meet the lime cylinder.

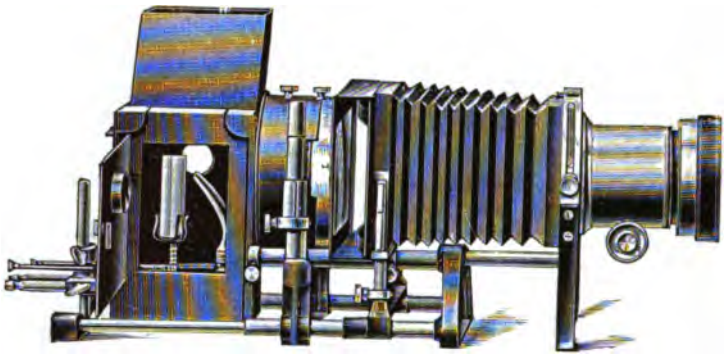


FIG. 303.—OPTICAL LANTERN WITH LIMELIGHT ILLUMINANT.

The third system is the oxy-hydrogen or mixed jet. This gives a light of very powerful intensity. In it the gases are mixed together in a small channel below the nozzle, and they come out together on to the lime. In the hands of an inexperienced person, this method would be a very dangerous one, for if the pressure on the gas bag were to be removed for even a single instant, the mixed gas or flame would be sucked back into the bag, and a tremendous explosion would be the result. To prevent this disaster, safety valves have been used.

The ether-oxygen or ethoxo limelight is similar to the last, except that vapor of sulphuric ether is used in place of the ordinary hydrogen gas. It gives a very beautiful light, but has several drawbacks, danger of explosion being one, so that it is but very little used.

The Electric Light.—For some time it has been apparent that the most perfect illuminant for the optical lantern would be the electric arc not only on account of its intense whiteness but principally for the reason that the light is confined more nearly to the theoretical point.

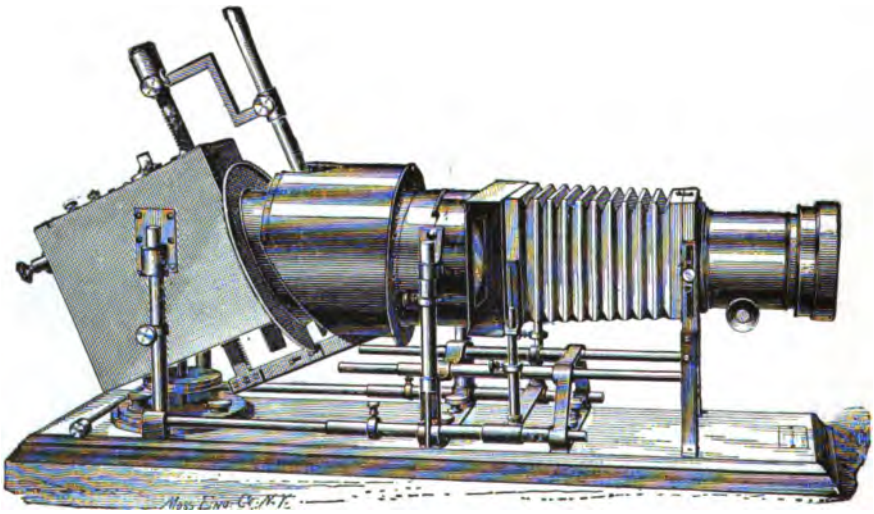


FIG. 304.—OPTICAL LANTERN WITH ARC-LIGHT ILLUMINANT.

The above cut shows one of the better forms of electrical lanterns manufactured by J. B. Colt & Co. In this form of lantern, the bellows, front and objective supports, can be readily removed, admitting of the use of the microscope or other scientific attachment, and various combinations of condensing lenses may be used as the case may require. The hood or light guard between the light and condensers is of unique and original design, consisting of two cylindrical parts, one of which surrounds the carbons, and the other is secured to the back of the lantern. As shown in the cut, the smaller section of the hood telescopes into the larger section, which is supported on the lantern without coming in contact with it, thereby obviating the direct conduction of heat from the lamp to the condensing lenses, and as the outside cylinder is of considerably larger diameter than the inner one, perfect ventilation is secured and also perfect freedom for the adjustment of the light in all directions in rela-

tion to the lenses. When exhibitors are located on a low tension continuous current, the automatic lamp has advantages over any other form, but if this is not the case and a high tension current or an alternating current must be used, a lamp of different construction is necessary. The one that this firm have constructed for this purpose is not automatic in its control of the carbons, but is provided with a simple mechanism whereby the carbons are moved toward each other every few moments as they are consumed. This lamp is exceedingly simple in its operation, and the adjustment of the carbons is no more difficult than the occasional turning of the lime in the well-known oxy-hydrogen apparatus.

The Condenser.—The object of the condenser is to collect as much of the light as possible, and pass it uniformly through the transparency. There are two principal forms—one consists of a pair of plano-convex lenses, mounted, with the curved surfaces nearly touching, and the other consists of a double convex lens associated with a meniscus, the concave side of the latter being next the radiant point.

The Lens, or objective, is required to receive the rays of light passing from the condenser through the picture, and to magnify and project them on to the screen. It should have a flat field and be free from distortion. Further, it should be achromatic.

How to Use the Optical Lantern.—In using the optical lantern the following hints will be found useful.* Wipe the front and condensing lenses with a piece of soft silk free from every particle of dust. Thoroughly dry new wick before putting it into the lamp; let the wick be saturated with oil before lighting. The best paraffin oil gives the brightest light. Diener's A1 safety oil, and Strange's A1 crystal oil, also the Vaseline Company's Luxor, are specially recommended. The best quality wick is indispensable to brilliant illumination. Cheap wicks and cheap oils are false economies, and answerable for very many failures and disappointments when exhibiting the lantern. A large and strong pair of scissors should be used to trim the wicks, or preferably the "Optimus" patent wick trimmer, as a perfectly straight and even edge to the cotton is necessary to the avoidance of an uneven flame and smoke. Cut off the protruding corners to allow the flame to draw evenly upwards. Light the lamp with wax vestas or tapers. The heads of matches or charred paper are liable to fall into the air passages between the wick tubes, so impeding complete combustion. When lighting the lamp, do not turn the wicks high immediately, but raise them little by little at intervals of a few minutes. This system, besides improving the flame, gradually warms the condensing and front lenses; if suddenly heated they are likely to crack. Cold air being allowed to blow on a heated condenser will also certainly cause unequal contraction, *i.e.*, a cracked glass. The oil reservoir and other exterior parts of the lamp should be wiped *perfectly* dry, otherwise the oil about them will vaporize and fill the apartment with a most unpleasant odor. The wick should be trimmed prior to each exhibition, and when not burning should be turned one-eighth of an inch below the top of wick tubes, so that they may be permeated with oil. A plentiful supply of pure air is an imperative necessity to perfect combustion or perfect illumination. In crowded rooms, opening a window or door will greatly improve the light of the lamp; insufficiency of air ensures a bad light and an unsatisfactory exhibition. Like ourselves, the lamp gives its best results when it enjoys pure air, clean surroundings, and pure food (oil).

With regard to the size of the disc produced by the lantern, the following remarks and table from the *Optical Magic Lantern Journal* will be found of very great use:

When one is called upon to give a lantern entertainment in a hall or room the following questions will be uppermost in the mind of the operator: 1. What size of disc can be obtained with a lens of a certain focus? 2. How far distant from the screen must the lantern be placed in order to get a disc of a certain size with a given lens of ascertained focus? Doubtless many more questions will arise, but these mentioned will be of the most importance. It is a "rule of thumb" practice for an operator to wheel his apparatus up and down a room in order to find the desired position from which to officiate, and the minds of any spectators will not be confirmed in the idea that the exhibitor thoroughly understands his business. How very much more simple and satisfactory is it to reason thus before starting for the place of entertainment: "A screen of —— feet diameter is required, so if I bring a lens of —— focus the lantern must be —— feet from the screen;" the length of the room being, of course, taken into consideration, in order to ascertain that it is possible to erect the lantern at the desired distance. This having been ascertained beforehand, all that is required is to take an objective of the desired focus, and measure off the necessary space between the screen and the place where the lantern should be set.

Supposing we are called upon to operate the lantern in a hall twenty-five feet in length, we first ascertain the size of disc desired, which we will suppose to be 10 feet. With an objective having a focus of six inches, how far from the screen must the lantern be placed in order to produce a ten-foot disc?

Here is the rule by which it can be ascertained:

Let A=focus of objective.
" B=diameter of slide.
" C= " disc.
" D=distance between the lantern and screen.

* From "Hints when Using the Optical Lantern," by Perken, Son and Rayment.

Multiply the diameter of the circle required (C) by the focus of the lens (A) and divide by the diameter of the slide (B).

$$\frac{C \times A}{B} = D = \frac{10 \times 6}{3} = 20 \text{ feet.}$$

It is thus seen that in order to produce a ten-foot disc with a six-inch objective the lantern must be placed twenty feet from the screen.

On the other hand, we may possess several lenses of different foci, and it is necessary that the screen and the lantern must occupy certain positions which we will suppose to be just twenty feet apart, and that the diameter of the disc must be ten feet. How are we to ascertain whether we must use a lens of four, five, six, seven, or other number of inches in focus?

Multiply the distance between the lantern and the screen (D) by the size of opening of slide (B), and divide by the size of disc (C).

$$\frac{D \times B}{C} = A, \text{ focus of lens} = \frac{20 \times 3}{10} = 6\text{-inch focus.}$$

Again: We have a lens of six-inch focus, and intend that twenty feet shall intervene between the lantern and the screen, and wish to know what size of disc can be produced. In order to calculate this it is necessary that we multiply the distance between the lantern and the screen (D) by the size of slide opening (B), and divide by the focus of the lens used (A), which gives us

$$\frac{D \times B}{A} = C \text{ size of disc} = \frac{20 \times 3}{6} = 10 \text{ feet diameter of disc.}$$

The following Ready Reference Table has been computed by the foregoing rule, and by a glance it will show the relations between lantern and disc with object-glasses of every focus from 4 inches to 15 inches.

READY REFERENCE TABLE.

Distance between Lantern and Screen.	Focus of Lens.										
	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.	13 in.	14 in.	15 in.
	Diameter of Disc.											
	ft. in.	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*
10 feet...	7 6	6 0	5 0	4 3	3 6	3 4	3 0	2 9	2 6	2 4	2 2	2 0
11 " ...	8 3	6 7	5 6	4 9	4 2	3 8	3 4	3 0	2 9	2 6	2 4	2 2
12 " ...	9 0	7 2	6 0	5 2	4 6	4 0	3 7	3 3	3 0	2 9	2 7	2 5
13 " ...	9 9	7 10	6 6	5 7	4 11	4 4	3 11	3 7	3 3	3 0	2 9	2 7
14 " ...	10 6	8 5	7 0	6 0	5 3	4 8	4 2	3 10	3 7	2 3	3 0	2 9
15 " ...	11 3	9 0	7 6	6 5	5 8	5 0	4 6	4 1	3 9	3 6	3 3	3 0
20 " ...	15 0	12 0	10 0	8 7	7 6	6 8	6 0	5 6	5 0	4 7	4 3	4 0
25 " ...	18 9	15 0	12 6	10 9	9 4	8 4	7 6	6 10	6 3	5 9	5 4	5 0
30 " ...	22 6	18 0	15 0	12 10	11 3	10 0	9 0	8 2	7 6	6 11	6 5	6 0
35 " ...	26 3	21 0	17 6	15 0	13 1	11 8	10 6	9 6	8 9	8 1	7 6	7 0
40 " ...	30 0	24 0	20 0	17 2	15 0	13 4	12 0	10 10	10 0	9 2	8 6	8 0
45 " ...	33 9	27 0	22 6	19 3	16 10	15 0	13 6	12 3	11 3	10 4	9 8	9 0
50 " ...	37 6	30 0	25 0	21 5	18 9	16 8	15 0	13 8	12 6	11 6	10 9	10 0

Examples.—An 8 inch focus lens, at a distance of 35 feet, will give a disc of 13 feet 1 inch. To produce a disc of 12 feet, with a lens of 10 inches focus, the lantern and screen must be separated by 40 feet. To produce a disc of 15 feet at a distance of 45 feet, will require a lens of 9 inches focus.

OPTICIANS' CEMENT.—A cement used by opticians for fixing lenses, prisms, etc., to chucks, holders, etc., while they are being ground. It is made of pitch 10 parts, wood ashes 1 part, and 1 part more or less of tallow, according to the temperature of the season.

OPTICS was defined by Sir David Brewster as that branch of knowledge which treats of the properties of light and vision as performed by the human eye. The modern divisions of this science may be stated to be as follows:—(1) Light and its sources; (2) transmission, velocity, and intensity of light; (3) reflection and mirrors; (4) single reflection and lenses; (5) dispersion and achromatism; (6) optical instruments; (7) the eye as an optical instrument; (8) phosphorescence and fluorescence, and (9) double refraction interference and polarization.

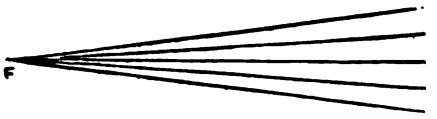


FIG. 305.

Light and its Sources.—Light is the agent which by its action on the retina excites in us the sensation of vision. Various hypotheses have been made as to the origin of light, the two most important being the emission or corpuscular theory and the undulating theory. These will be found more clearly defined under the heading **Light** (*q.v.*)

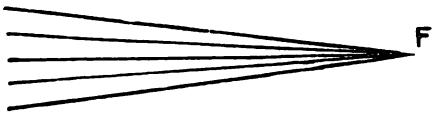


FIG. 306.

Transmission, Velocity and Intensity of Light.—Luminous bodies are those which emit light such as the sun, and ignited bodies such as a candle. *Transparent* or diaphanous bodies are those which readily transmit light. *Translucent* bodies transmit light but partially, as objects cannot be seen through them as in the case with transparent bodies. *Opaque* bodies do not transmit light.*

It is a well-known fact that light always travels in straight lines, and cannot turn a corner. The term *ray of light* is used to indicate the straight line along which light progresses. If the luminous body be central, rays of light are emitted from all its points and in all directions. A collection of rays emitted from a luminous point, and circumferentially so limited in their passage as to form a conical outline, is called a *diverging pencil of rays*, the apex of the cone from which they proceed being called the *focus* of the pencil. See Fig. 305.

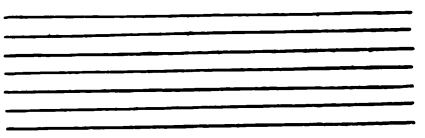


FIG. 307.

If the rays proceed from so distant a point that any divergency is inappreciable, the rays are termed parallel rays. See Fig. 307.

Every luminous body emits divergent rectilinear rays from all its points and in all directions. As light travels in straight lines it will be easily understood that if any opaque body be interposed between the source of light and the eye it will prevent it from being seen. The light cannot penetrate into the space behind it, and this space is termed the shadow.

When, however, they are made to converge to a common point they are described as a *converging pencil of rays*, and the point at which they meet is termed the focus. See Fig. 306.

If a small aperture be made in an opaque substance, such as, for instance, a piece of tinfoil, and luminous rays made to pass through this aperture into a dark chamber and thrown on to a screen, they will form images of the external objects. See Fig. 308.

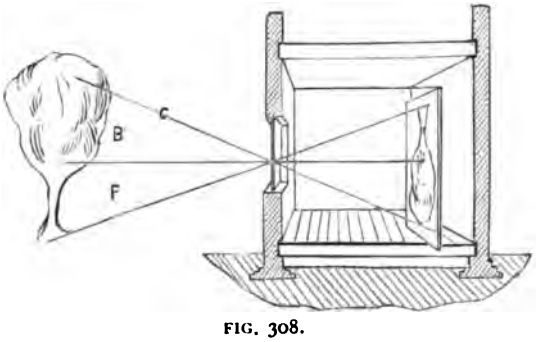


FIG. 308.

These images are always inverted owing to the fact that the luminous rays proceeding from the external objects across one another on their passage, as shown in the diagram

Light moves at a velocity of about 190,000 miles in a second. M. Foucalt constructed an apparatus for measuring the velocity of light based on the use of the rotating mirror adopted by Wheatstone in measuring electricity. With this arrangement he calculated the speed to be 185,157 miles per second. The intensity of illumination of given surface is subject to the two following optical laws:

I.—*The intensity of illumination on a given surface is inversely as the square of its distance from the source of light.*

II.—*The intensity of illumination which is received obliquely is proportional to the cosine of the angle which the luminous rays make with the normal to the illuminated surface.*

The first law is one that should be carefully noted by the photographer on exposing sensitive material to the action of light rays.

Reflection and Refraction.—When a ray of light meets a polished surface it is reflected according to the two following laws:

* No body can be said to be absolutely opaque, as all are more or less translucent when cut or formed into sufficiently thin sheets.

I.—*The angle of reflection is equal to the angle of incidence.*

II.—*The incident and the reflected ray are both in the same plane, which is perpendicular to the reflecting surface.*

All the phenomena of reflection of rays of light from polished surfaces, whether plane or curved, take place in accordance with these two laws. If the polished surface be a plane, or have a regular curvature, the reflected rays of light produce images of the objects from which the rays have proceeded. If the surface be roughened, the reflection will still be produced, but the rays are irregularly dispersed, and no images are produced. By the term reflecting surfaces is usually meant polished surfaces, but even when a ray of light meets a perfectly polished surface only some of it is reflected. A portion of it is absorbed by the medium forming the substance of the polished surface, another part is diffused, and another is transmitted, if the medium be transparent.

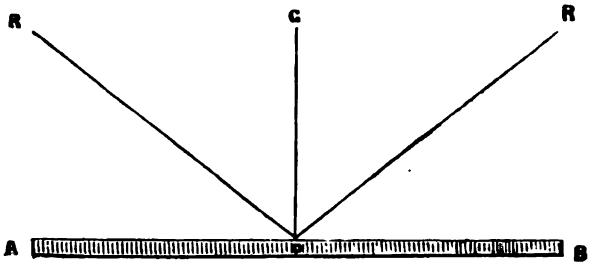


FIG. 309.

Let A B (Fig. 309) be a plane reflecting surface, and R D a ray of light incident upon it, the ray will be reflected in the direction of D R′ in the same plane as the incident ray, the plane being perpendicular to the reflecting surface, and making with that surface an angle R′ D B equal to the angle R D A. The normal C D is the straight line perpendicular to the surface A B, which makes the incident ray R D and the reflected ray R′ D equal angles.

Bodies having polished surfaces are termed mirrors, and show by reflection images of objects presented to them. The place at which objects appear is their *image*. The quantity of light reflected from the surface of a mirror depends, firstly, upon the degree of perfection of its polish; secondly, on the color of its surface; and thirdly, upon the incidence of the luminous rays which strike it. Mirrors are divided, according to their form, into the following: *Plane, concave, spherical, parabolic, conical, &c.*

The commonest example of the plane mirror is the ordinary looking-glass. Its effect is shown in Fig. 310. The eye not only sees the object, but also a reflection of it, because the light that emanates from the ball in the direction of the line towards the mirror has its direction changed and enters the eye. If light from the object reaches the eye in two distinct directions the effect is precisely the same as if there were two objects, because two images are produced upon the retina. This reflection, which, although it appears like an image, is not one, is termed in optics a *virtual image*. When the reflected rays converge, however, as is the case with concave mirrors, the rays coincide at a point in front of the mirror on the same side as the object. They then form an image termed a *real image* that can be received on a screen.

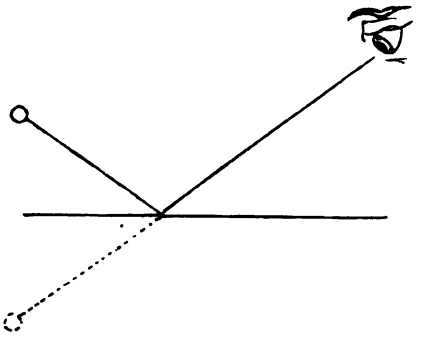


FIG. 310.

Polished metal mirrors give only one image; glass mirrors give several, however. If a candle be placed near a looking glass, and its reflection received obliquely, a feeble image is first seen in front of the principal and distinct one. Behind this several other images are observed, the intensities of which gradually diminish as they disappear. This phenomenon is due to the fact of the looking-glass possessing two reflecting surfaces.

Oblique rays are partly reflected from the front surface of the glass which gives the faint image first mentioned, in addition to the principal image reflected from the back surface. The other images are produced by the light from the back, or prepared surface, being reflected back again from the front surface of the glass, and so going backwards and forwards, producing numbers of images which naturally get fainter and fainter. The passage of the ray is more clearly shown in Fig. 311. The thick line indicates the passage of the light ray, and the dotted lines show the reflections producing the false images.

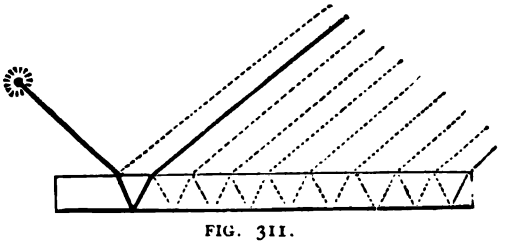


FIG. 311.

It is for the above reason that glass mirrors cannot be used for many purposes. For instance, in the making of reversed negatives, metal mirrors will be found preferable.

We have already pointed out that, besides plane mirrors, there are several other kinds; those now frequently used are the spherical and parabolic reflectors.

A concave mirror causes the pencils of light that impinge upon it to converge. As the law that the angles of incidence and reflection are equal applies to all reflecting surfaces, it will not be difficult to trace upon paper the effect of any mirror upon the direction of any ray of light. In Figs. 312, 313 and 314* the arcs that stand for curved mirrors are struck from the points marked C, and this point is called, in each case, the *center of curvature* of the mirror.

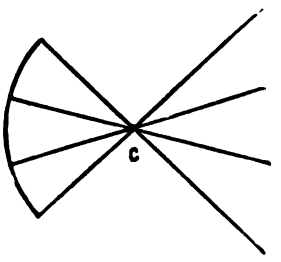


FIG. 312.

If a luminous point be placed in the center of curvature of the mirror (c. Fig. 312) the rays emanating from it travel in the direction of the radii of the sphere of which the mirror is a part, and those rays that impinge upon the mirror are reflected back along their original paths to the luminous point, and add their effect to the light emanating in the opposite direction. If, however, the luminous point be removed to a position half-way between the center of curvature and the surface of the mirror, the light reflected forms a bundle of approximately parallel rays, as shown in Fig. 313, excluding the dotted lines, and conversely, if parallel rays impinge upon such a mirror, they are brought to a point of focus half-way between the center of curvature and the mirror. This point is termed the principal focus P F. In Fig. 314 we see at once that a luminous point placed farther from the mirror than its center of curvature, has its light that impinges upon the mirror brought to an approximate focus at a point between the principal focus and the center of the curvature A. Conversely, a luminous point placed at A would have its light concentrated at B, these two points, or any two points similarly related to each other, being termed *conjugate foci*. The dotted lines in Fig. 314 serve to show that if the curve of the mirrors were continued the concentration at the principal focus is not even approximate. This lack of focussing power is termed *spherical aberration by reflection* to distinguish it from the spherical aberration by refraction, which occurs in the case of lenses.

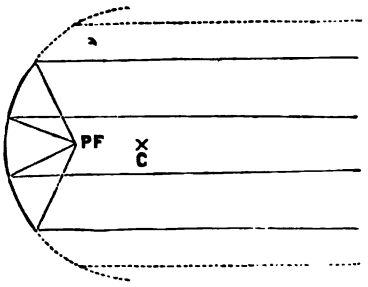


FIG. 313.

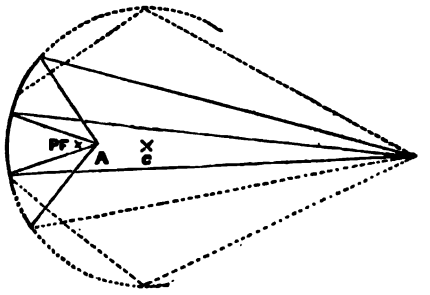


FIG. 314.

Parabolic mirrors are concave mirrors, whose surface is generated by the revolution of the arc of a parabola, A B about its axis A A. (Fig. 315.)

In spherical mirrors the rays parallel to the axis converge only approximately to the principal focus. Parabolic reflectors are free from this defect. It is a property of a parabola that the right line F B, drawn from the focus F to any point B of the curve, and the line B C parallel to the axis of A A', make equal angles with the tangent D D' at this point. Hence all rays parallel to the axis after reflection meet in the focus of the mirror F, and conversely when a source of light is placed in the focus the rays incident on the mirror are reflected exactly parallel to the axis. The light thus reflected tends to maintain its intensity even at a great distance.*

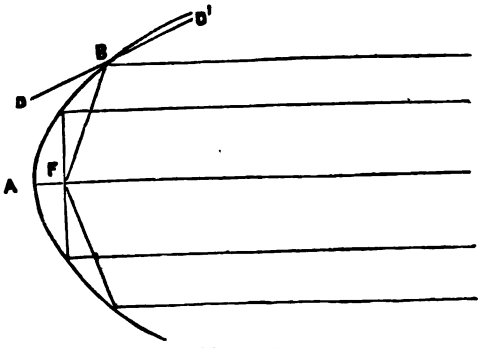


FIG. 315.

The use of mirrors of different kinds for photographic purposes is large. In the early days of the Daguerreotype a camera was constructed having a concave mirror instead of a lens. Owing to many drawbacks, however, this method was not found to be an advantage over the lens. In stellar photography, however, the mirror possesses several advantages over the lens. It can be made larger at less expense, gives a much brighter image, and is entirely free from chromatic aberration. Heliostats are adjustable mirrors, which receive their movements from clockwork in such a manner that the solar rays reflected remain motionless in a given direction.

Convex mirrors do not possess real images ; they are, therefore, of comparatively no use in photography.

Single Refraction and Lenses.—A ray of light proceeds in a straight line so long as the medium through which it is traveling is of uniform density. If, however, it passes *obliquely* from one medium to another of a denser kind, it is *refracted towards* a line drawn perpendicularly to the surface of this medium at the point of incidence ; conversely on passing obliquely from a denser into a rarer medium it is *refracted from* the line. If the ray passes perpendicularly from one surface to another it continues its course in a straight line. Refraction is more clearly shown

* Chapman Jones' "Science and Practice of Photography." ‡ Ganot's Physics."

in Fig. 316. The incident ray R C is refracted in the direction C R' by passing obliquely from air into water. The path of the light in the denser medium forms a smaller angle with the perpendicular A B than it does in the rarer medium. The line D E is the sine of the angle of incidence, and the line G F the sine of the angle of refraction. Analysis has shown that the direction of refraction depends on the relative velocity of light in the two media. The laws of single refraction are :—(1) Whatever the obliquity of the incident ray the ratio which the sine of the incident angle bears to the sine of the angle of refraction is constant for the same two media, but varies with different media. (2) The incident and the refracted ray are in the same plane, which is perpendicular to the surface separating the two media.

The proportion between the lines D E and G F, when the media concerned are air and water, is approximately as 4 to 3. These proportions, indicated as fractions, are the refractive indices, *i.e.*, $\frac{4}{3}$, or 1·33. If, however, the media are considered in an inverse order, that is to say. if the light passes from water to air, the index of refraction is consequently reversed, it would then be $\frac{3}{4}$. (See also **Refraction.**)

Lenses are transparent media, which, from the curvature of their surfaces, have the property of causing the luminous rays which traverse them to either converge or diverge. According to their curvature they are either spherical, cylindrical, elliptical, or parabolic. Those used in optics are exclusively spherical. They are usually made of crown glass and of flint glass. These two glasses possess different refractive indices. Combination lenses of the two glasses are made. (For detailed information regarding lenses, see under **Lens.**)

Dispersion and Achromatism.—To avoid confusion we have, on explaining the phenomenon of refraction, avoided mention of the phenomenon known as *dispersion*. When white light passes from one medium to another it is decomposed into several kinds of light. An experiment proving this can easily be made by boring a small hole in the shutter of a darkened room, to allow of a pencil of the sun's rays to pass through. This pencil will give you a round and colorless image of the sun. If, now, a flint glass prism be interposed in its path, the beam on emerging from it is refracted and produces on a screen a vertical band, rounded at the ends, colored in all the tints of the rainbow. This is termed the solar spectrum, and contains an infinity of different tints all imperceptably merging into each other. For the sake of simplicity, however, it is customary to distinguish seven principal colors, these are, violet, indigo, blue, green, yellow, orange, and red. This is the order in which they are arranged in the spectrum, the violet being the most refrangible, and the red the least so. See also **Spectrum.**

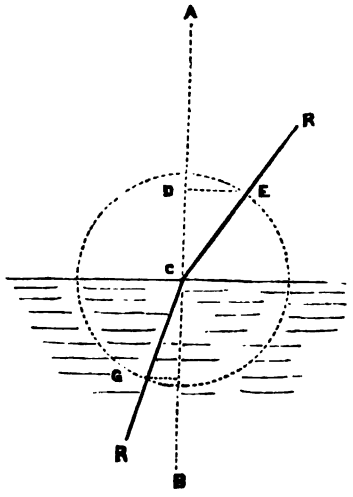


FIG. 316.

This separation of white light into its component colors sometimes occurs in lenses, and is termed *chromatic aberration*. See under **Aberration.**

Optical Instruments.—By the term optical instrument is meant any combination of lenses or mirrors. They are divided by Ganot into three classes, according to the ends they are intended to answer, viz. :—(1) *Microscopes* which are designed to obtain a magnified image of any object whose real dimensions are too small to admit of its being seen distinctly by the naked eye. (2) *Telescopes* by which very distant objects, whether terrestial or celestial, may be observed. (3) Instruments to project on a screen a magnified or diminished image of any object, which can thereby be either depicted or rendered visible to a crowd of spectators, such as the camera lucida, the camera obscura, photographic apparatus, etc. The two former classes yield virtual images ; the last, with the exception of the camera lucida, yield real images.

The Eye as an Optical Instrument.—The structure of the eye may be considered as a camera obscura, of which the pupil is the aperture, the crystalline the condensing lens, and the retina the screen upon which the image is formed. See **Vision.**

Phosphorescence and Fluorescence.—See under these headings.

Double Refraction, Interference and Polarization.—A large number of crystalline bodies possess the property of double refraction, in virtue of which a single incident ray, in passing through any one of them, is divided into two, or undergoes what is termed *bifurcation*. An object, therefore, viewed through one of these crystals appears double. Iceland spar, crystallized carbonate of calcium, possesses the property in a most remarkable degree. The term *interference* is given to the reciprocal action which two rays of light exert upon each other when emitted from two neighboring sources, and caused to meet each other under a very different angle. If two similar waves start from the same place, at the same time, they increase each others intensity, and the result is a wave of double light ; but if one wave is half an undulation in advance of the other, the crest of one occupies the position of the hollow of the other, and the result is a dead level. If the intervals of starting are less than half a wave length, the result is a series of smaller waves, the magnitude of which depends upon the distance which one wave has

in advance of the other. The interference of the waves of light may be produced in many ways by diffraction, or by reflection, from thin films, such as soap bubbles, or from minute particles.* Polarization of light is the state into which the ethereal undulations which cause the sensation of light are brought under certain conditions. These undulations are perpendicular to the line of transmission of the wave, as in a stretched cord, but in a ray of common light appear to take place successively in all directions, in the manner shown in diagram A, Fig. 317 (but with the transitions far more gradual), the vibrations successively passing through rectilinear, elliptical and circular phases with inconceivable rapidity. If now the vibrations become or are rendered stable in any form of orbit, the light is in the condition known as polarized, and the state is one of plane, elliptical or circular polarization, according as the orbit resembles B, C, or D. The most familiar and simple form is that of plane polarization. This may be produced in various ways, the apparatus producing such modifications being termed a polarizer. When produced, however, the effects can only be perceived by examining them through another piece of apparatus called the analyser. The two combined with the necessary adjustments, form a polariscope, of which there are many forms.

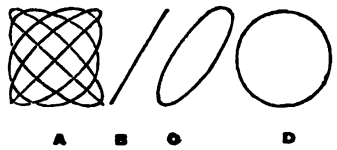


FIG. 317.

OPTIGRAPH.—A form of camera used for the purpose of copying landscapes. The rays from the object to be drawn are to be reflected from a plane mirror through the object glass of the instrument to a speculum, and thence through an eye-glass to the eye. Between the eye and the speculum is a piece of parallel-faced glass with a small dot in its center, exactly in the focus of the eye-glass. By moving the pencil, the dot seen in the field of the telescope is passed over the outlines of the object, which are at the same time traced on the paper by the pencil. *

ORANGE LIGHT.—A non-actinic light used in photography when handling sensitive materials. A very good temporary orange light can be produced by simply surrounding a candle with a piece of orange-colored gelatine, and suspending a piece of red paper above to receive the top light. A good orange-colored material may be made by dyeing with a solution of equal parts of annotta and pearlash, or by a bath of one part of annotta dissolved in a lye of one part each of lime and pearlash, and two parts of soda. If a redder shade is desired, the dyed stuff can be passed through water acidulated with citric acid, vinegar, or lemon-juice.

ORGANIC ACIDS.—Carbon acids derived from hydro-carbon.

ORGANIC BASES.—The alkaloids of vegetable and animal origin and the derivatives of ammonia produced by the destructive distillation of complex organic matter, and those formed chemically by the substitution of hydrogen of ammonia by organic radicals.

ORGANIC CHEMISTRY.—The chemistry of the carbon compounds in which the hydrogen or nitrogen of the substance is directly united with carbon. The marvellous discoveries of the last few years have made it impossible to state where organic chemistry ends and inorganic chemistry begins. In general terms, however, it may be stated that inorganic chemistry treats of the metals, or of the metals in combination with one or more of the non-metallic bodies.

ORGANIC RADICAL.—A group of atoms containing one or more atoms of carbon, of which one or more bonds are unsatisfied. It can be a monad, dyad, or tryad, according to the number of monad atoms necessary to complete its active atomicity.

ORGANIC SUBSTANCE.—A substance or body having organs in action, and consequently life. The category includes animals and plants.

ORNAMENTAL BACKGROUND.—See **Background.**

OROHELIOGRAPH.—An instrument invented by M. Noë, and described in a memoir to the Photographic Society of France. It consists of a camera, the sensitive plate forming the inner horizontal floor, and the lens looking up perpendicularly to the sky. Over the lens is placed a silvered mirror, half-globe shaped, completely circular on its plain and parabolic through its vertical section. The result is that an image of all surrounding objects reflected from this half-ball shaped mirror is received by the lens and transmitted thereby to the sensitive plate underneath with its surface forming a right angle with the axis of the lens and circular mirror. By this means a circular panoramic view of the horizon is obtained as seen from the station the oroheliograph occupies.

ORTHOBOIC ACID.—See **Borax.**

ORTHOCHROMATIC COLLODION EMULSION.—A collodion emulsion rendered ortho-

* See Hunter's "Encyclopædic Dictionary." † Rodwell's "Dictionary of Science."

chromatic by the addition of so-called color-sensitizers, the effect of which is to produce photographic negatives more correct with regard to the color gradations as apparent to the eye. Mr. J. M. Eder's formula is as follows:

The emulsion is prepared with—

A.—15 grammes crystallized nitrate of silver dissolved in 12 c.c. water, and then 90 c.c. alcohol of 95% is added; the whole is then mixed with 150 c.c. of 4% raw collodion.

B.—15 grammes pure crystallized calcium bromide are dissolved at a gentle heat of 75 c.c. of an alcoholic solution of (1:800) eosine, and then added to 150 c.c. of 4% raw collodion.

In the dark-room the collodion A, containing the bromide, is to be gradually added, well shaking the whole time, to the collodion containing the silver, until only about 5 or 10 c.c. of the bromide and collodion remain. The emulsion is then tested for an excess of silver nitrate. This is done by pouring a small quantity of the collodion on to a glass plate, and, when stiff, let fall a drop of potassium dichromate solution upon it. If a large excess of nitrate of silver be present, a deep colored spot of silver chromate will be produced. A further quantity of the plain collodion is then added, and the test repeated. When the drop of dichromate solution gives only a pale orange-reddish spot the emulsion is fit for use.

This collodion emulsion only works well when a slight excess of silver nitrate is present, inducing the formation of eosine of silver. If no excess be present, the emulsion will be very insensitive, while, on the other hand, if the excess be too great, the film is much more sensitive, but is liable to produce dirty and foggy images. The emulsion may be used at once, but the results are better if it be kept for twelve or twenty-four hours. The plates are coated in the usual manner, and dipped in a vessel of spring water, until the water ceases to be repelled at any part of the surface. It is best to expose while still wet; when dry they are much less sensitive. The time required for exposure is about half that nececsary for wet collodion plates with the iron developer. Most painting or colored objects may be photographed without the interposition of a yellow screen. A harsh blue may be softened down by using a screen of collodion stained with aurantia. The following will be found a serviceable developer:

A.

Water	100 parts
Sodium sulphite	10 parts
Potassium bromide	3 parts
Citric acid	1 part
Pyrogallic acid	2½ parts

B.

Ammonia	1 part
Water	6 parts

Before use mix 100 c.c. of water, 10 c.c. of A, and 10 c.c. of B solutions.

ORTHOCHROMATIC or **ISOCHROMATIC PHOTOGRAPHY.**—Synonymous terms applied to a process of obtaining photographic images of objects in, or nearly in, their true respective tone values. Ordinary gelatine plates do not, as is well-known, represent objects in their true relative degrees of light and shade as apparent to the eye, for the reason that they are most sensitive to the blue and violet rays, less sensitive to the green, and very slightly sensitive to yellow, orange, and red, whereas the eye is most sensitive to yellow and least sensitive to blue and violet. Those rays which produce the greatest effect on the eye have therefore the least action on the photographic plate, and *vice verso*.

As an obvious consequence of this defect, blue and violet objects appear much too bright in a photograph while green, yellow, and red appear too dark. Thus, if we were to make a photograph of a yellow cross on a blue ground it would appear in the photograph as a dark image on a lighte background, whereas if an artist were making a picture in black and white he would represent it the other way, that is to say, the yellow cross would appear lighter than the blue ground, but in the photographic image it would be darker.

Fig. 318 is a table of curves taken from Professor Bothamley's paper on this subject. The curves represent the intensity of action, they rise to represent a large effect, and fall to show a diminution. The vertical lines stand for the Fraunhofer lines, and are lettered accordingly. Number 1 curve shows the visibility of the spectrum; number 2 the effect produced by exposure and development of an ordinary gelatine bromide plate; and number 3 the result when it is prepared with a sensitizer composed of an ammoniacal solution of rose bengal.

The effect of this defect in photography will be at once apparent. Untrue images of colored objects are obtained, the foliage in landscapes appears too dark, the blue sky, or water reflecting it too bright. The atmosphere intervening between the camera and objects afar off causes a bright blue haze, destroying all the detail in the distance. In portraiture the effect is

quite as destructive, the tints of the flesh appear too heavy, sun freckles or any other slightly yellowish mark, perhaps almost imperceptible to the eye, appear glaringly prominent as black spots or patches.

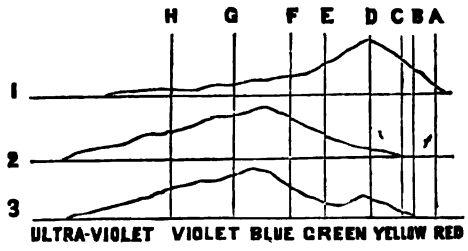


FIG. 318.

As far back as 1865, it was noticed that lenses which were of a slight yellowish tint, produced perhaps by long exposure to light, gave photographic representations of colored objects in better relation. This led to the discovery that the interposition of a yellow transparent screen between the object and the plate, either before or behind the lens, would, by cutting off the greater portion of the blue and violet rays, and giving the green, yellow, and orange rays more time for action, produce images with nearly the same luminosity that the colors in the objects appear to the eye.

In 1873 Vogel* found that by treating certain plates with certain coal-tar dyes it was possible to make them sensitive to the less refrangible rays, namely, the green, yellow, orange, and red. Later on Waterhouse recommended eosine for the purpose, and a large number of dyes were afterwards found out to be serviceable for this purpose by many able scientists, such as Vogel, Waterhouse, Tailfer, Eder, Bothamly, Wellington, Ives, Abney, Schumann, and others. Among these dyes may be mentioned the following: eosine, cyanine, rose bengal, erythrosine, chlorophyll, rosaniline, and azaline.

The names given to this process of photography are *Orthochromatic* from Greek *orthos*—right, true; and *chroma*—color, and *Isochromatic* from *isos*—equal, and *chroma*—color. Both these terms, it will be seen, are exceedingly unsuitable, and liable to mislead the student, as they should in reality be applied to photographs in true or natural colors. Other terms, such as orthophotic, orthoactinic, paractinic, etc., have been suggested, but the term orthochromatic will no doubt remain for some time to come.

ORTHOCHROMATIC OR ISOCHROMATIC PLATES.—Photographic plates prepared with a dye, either added to the emulsion previous to coating the glass, or applied in solution to the ordinary gelatino-bromide dry plate. By this means better and truer color gradation is obtained.

These plates may be obtained commercially, and are equally adapted for landscapes and for general work in the studio. They will keep equally as well as ordinary gelatine plates, they are quite easy to work, and owing to their color sensitiveness, give better gradation and a more truthful representation of natural objects in the light and shade of the photograph. These plates are made in three degrees of sensitiveness, *i.e.*, "medium," "slow," and "instantaneous." The following instructions for use are given:

These plates are more sensitive than ordinary plates to the usual red or yellow light of the dark room; therefore great care must be taken to use only a dull light of a deep ruby color, and to shield the plate as much as possible during the manipulations. It will be found a good plan to cover the dish until the development is nearly completed. An amount of light which would be perfectly safe with ordinary gelatine plates, is quite sufficient with these color-sensitive films to cause fog and spoil the negative.

Exposure.—These plates are extremely sensitive to ordinary daylight, and require very short exposure in the camera. If artificial light be used, such as gaslight, their relative sensitiveness will be found many times greater than the most rapid gelatine plates of the ordinary kind.

For photographing colored objects, such as oil paintings by daylight, it is sometimes advisable, in order to obtain to their fullest extent the isochromatic qualities of the plates, to use a color screen of yellow glass behind the lens, and proportionately increase the exposure. For ordinary purposes no screen is required. (See **Orthochromatic Screen.**)

Development.—Any good formula for developer may be used. For pyro-development the following is recommended:

THE STOCK SOLUTIONS FOR DEVELOPING.

No. 1.

Pyrogallic acid	1 ounce
Citric acid	40 grains
Water	7½ ounces

No. 2.

Bromide of potassium	120 grains
Distilled water	7 ounces
Strong ammonia, 880	1 ounce

The above will keep good, if well corked, for months.

To make the developer, add one part of No. 1 to nineteen parts of water, and in another bottle mix one part of No. 2 with nineteen parts water. The dilute solutions should be made fresh every day.

* Die Photographie farbiger Gegenstände in den richtigen Tonverhältnissen.

When required to develop a plate, mix equal parts of these two solutions just before use; place the exposed plate face up in a shallow dish or tray, and pour the mixture steadily over the plate, avoiding air bubbles; rock the dish gently, taking care to keep the plate well covered with the solutions. Do *not* hurry the development, but allow the plate to remain in the solution *after all the details are visible*, until the required density is obtained. With these plates and the above developer there is no danger of fog, except from light or over-exposure.

FIXING.

Hyposulphite of soda	4 ounces
Water	16 ounces

Immerse the negative in the above, which should be freshly mixed.

Clearing Solution.—After fixing, rinse under the tap, then flood the plate or immerse for one minute in the following solution:

Alum	1 ounce
Sulphuric acid	½ ounce
Sulphate of iron	3 ounces
Water	20 ounces

Wash well and dry as usual.

Negatives on these plates develop without difficulty to full printing density. If found too intense they may be further reduced by allowing them to remain a longer time in the clearing solution.

Considerable advantage is to be obtained by using these plates both for portrait and landscape photography. In the latter the improvement is at once seen, not only in the corrected rendering of the detail in the foliage and foreground, but also in the general effect of correct light and shade with an atmosphere that would be ruinous in ordinary photography, wholly obliterating the distant background.

In a recent issue of *Les Annales Photographiques*, M. L. Tranchant gives some important additions to the subject of orthochromatism, and we translate extracts from his article to form a valuable addition to the series of articles upon the subject by Mr. P. C. Duchochois, which we recently published,* and who may fairly be said to be the propagator in this country of the orthochromatic process. For many years past he has published numerous articles pointing out the advantages of orthochromatic plates over the ordinary ones for all classes of work, whether studio, landscape, or instantaneous.

M. Tranchant in his article first deals with the subject of orthochromatism by means of coloring baths. Referring to the fact that plates prepared by the processes recommended by Vogel, Mallmann, and Scolik, do not keep for any length of time, he gives a method which he declares has not this inconvenience attached to it. Supposing that in dyeing to each argentic molecule a colored molecule is attached, which absorbs certain radiations, the natural necessity is that this substance shall not alter the silver bromide or gelatine. It is for this reason that only the following colors can be employed.

Eosine, erythrosine, cyanine, croculeine, and azuline.

1. VOGEL'S FORMULA.

Water	90 parts
Alcohol	35 parts
Ammonia	1 part
Azaleine 1 p. 100 solution	1 part
Or, 1:500 solution	5 parts

2. SCOLIK AND MALLMANN'S FORMULA.

Water	175 parts
Ammonia	4 parts
Erythrosine 1:1000	25 parts

But whatever be the coloring matter employed, the following bath, he says, can be used for every one:

Water	75 parts
Alcohol	25 parts
Ammonia	1 part
Coloring mattering 1:100	1 part

The plates prepared with a bath of azuline maintain their properties indefinitely.

He gives the following table of the colors which are best rendered by the various organic substances employed as dyes:

Eosine for	*green, green-yellow*
Cyanine for	*red and orange*
Azuline for	*green, red and yellow*
Erythrosine for	*green and orange*
Azaleine for	*green and orange*
Croculeine for	*all the colors*

* THE PHOTOGRAPHIC TIMES, Vol. XXIV., pp. 6 *et seq.*

Apparently croculeine would be the most complete substance, but it is not much employed, owing to its so often being of inferior quality and difficult to obtain commercially.

All plates thus prepared do not keep well, owing, says the author. to the alcohol and ammonia added to the bath. We think it to be more likely to be due to the latter substance, however, unless to impurities in the alcohol.

Buy the eosine soluble in water; as to the azuline a little *rectified* alcohol at 90 deg. should be added, or, what is better, dissolve the azuline in alcohol, add the water, boil the solution in a porcelain vessel and allow it to cool.

For use, pour the color bath, after having filtered it, into a porcelain tray, and allow the plate to absorb the liquid for one minute; drain and set it aside to dry in the dark at the temperature of 25 deg. C. (73.4 Fahr.).

All these operations should be made by the red light of the dark-room, and the plates

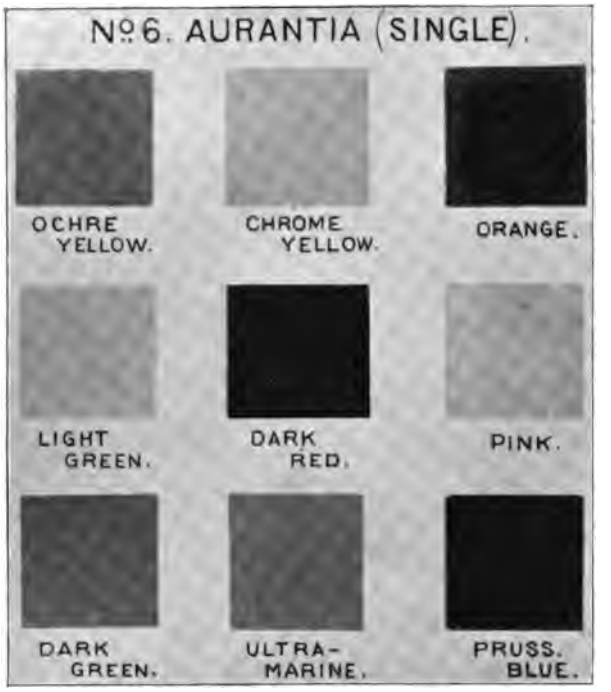


FIG. 319.

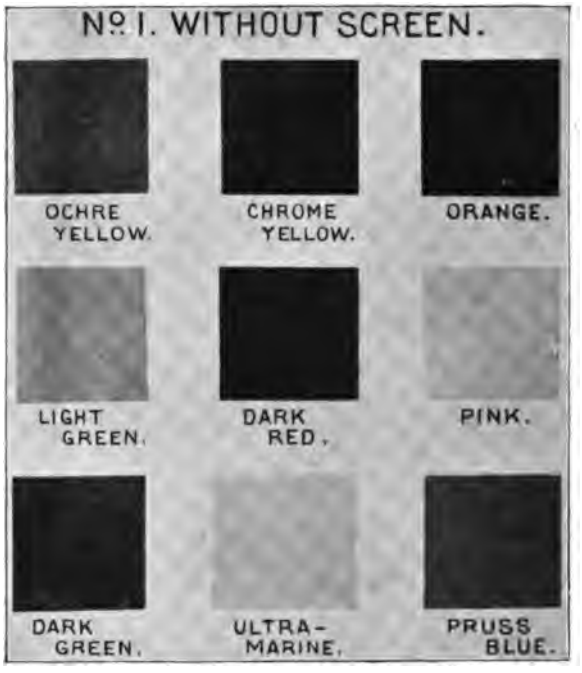


FIG. 320.

carefully guarded, even from this light, when not actually required. Plates prepared in this manner are said to be very good and keep well for a long time. They have but one defect: the exposure should be three times longer with the azuline plates. It is for this reason advice is given to prepare them only with extra rapid plates. Moreover, the latter plates, whether they be orthochromatized by azuline (which renders them very sensitive to green and yellow, a little less to red), or prepared with eosine (which does not render the red), must, in certain cases, be completed by the use of a screen—one of a light green color.

Referring to orthochromatism by colored screens the author says that all the plates of commerce, and even those prepared with eosine, erythrosine and azuline, should, in order to render the reds, be exposed for at least half the time of exposure by a light green screen.

Those prepared for yellow and green should be completed for the green by a screen tinted with rose-eosine.

It is well known that each color has a complementary one; project a beam of solar light through two glasses selected with care; for example, a green and red glass, and if the light filtered, as it were, through these glasses is white, it is certain that the green superposed to the red is the complementary color of this red. It is, however, absolutely impossible to obtain colors so pure that the mixture will produce white. A dirty gray is the nearest approach to this effect that can be obtained.

But as there are only six fundamental colors from which all the others are formed, there will only be six useful screens:

Red.....Green
Yellow.....Blue
Violet.....Orange

The orange is composed of yellow and red, and the violet of blue and red, hence these two last

screens are not required. There remain therefore four screens: red, green, blue and yellow, which must be arranged two by two. But in most cases three screens are sufficient, thus:

Red for green	2
Green for red	1
Blue for yellow	1

To obtain all the tints of a landscape, these three screens should succeed one another during an exposure, proportionate to the numbers indicated, viz.: $2 \times x$ seconds for the red, $1 \times x$ seconds for the green, and $1 \times x$ seconds for the yellow. It suffices to prepare them beforehand in a manner sufficiently transparent, but nevertheless colored enough to obtain the result desired.

To prepare the screens faultless pieces of glass should be selected, colored light green, light red, and light blue. They should be rounded in a shape enabling them to be placed in the tube of the lens.

It is very difficult to find colored glass of the required quality, which must be of a pure color, and having perfectly plane sides; therefore, it is, as a rule, substituted:

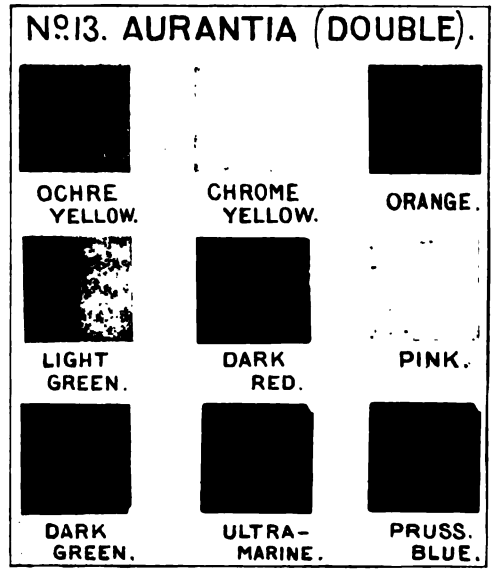


Fig. 321.

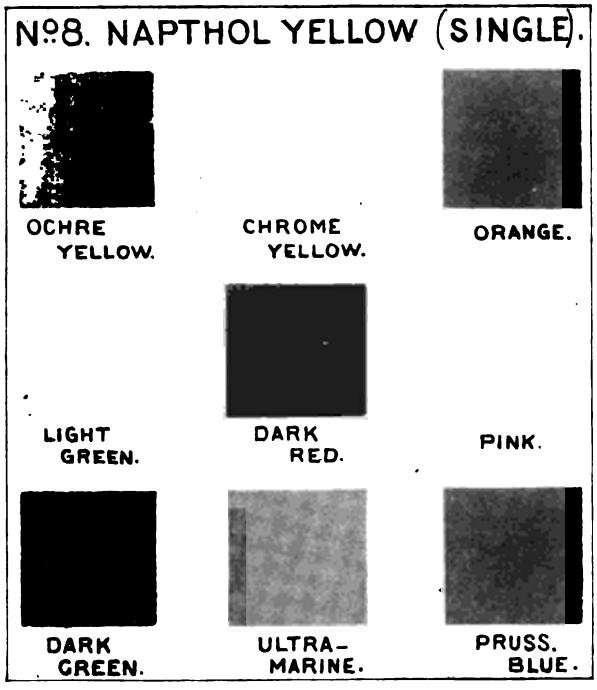


Fig. 322.

1. By an ordinary glass covered with a transparent film containing the colored medium.

2. By a pellicle or film of collodion, or of celluloid containing the color.

For the first method very fine and thin glasses are cut into shape, and coated with a small quantity of collodion very lightly colored with eosine. It is of importance that the film be very equal. We advise using a very thin collodion, and coating twice, draining the superfluous collodion from opposite corners, otherwise there is always a tendency for the collodion to be thin at the top and thick at the parts where the solution was poured off.

The green glass is prepared in the same manner with green lumière, and the blue glass with aniline blue.

With the second method on a glass plate is prepared for stripping, and the red collodion poured over it in the same manner as already recommended, then after stripping the film it is pasted on a cardboard diaphragm having the proper opening $f/10$, $f/20$, $f/30$.

The green and blue screens can be prepared in the same manner.

To prepare triple and quadruple screens to reproduce all the tints the following method is given:

A strip of glass is cut the width of the slide of a drop shutter and two-thirds longer. It is divided into five parts; one is covered with black paper, and the second coated with a very thin film of white gelatine colored with eosine.

The third part should be colored with green lumière by the same process; the fourth with aniline blue, and the fifth on both sides covered with black paper. This screen must be held during the proper exposure in such a manner that the light passes successively through each colored part in order to obtain the colors of the original with their relative intensity.

The amateur can, however, modify the form of the screen as he thinks proper, provided it has the following qualities:

1. Perfect opacity of the parts 1 and 5 covered with black paper.
2. Perfect transparency of the screens 2, 3, and 4
3. A separate stop for each screen is arranged in proper size in order to regulate the exposure.

In a recent issue of the PHOTO. TIMES Mr. Milton B Punnett discusses the question whether an ordinary plate can render correct color value, that is, reproduce in monotone the relative brightness of colors as they appear to the eye? He says: "Many practical men such as F. E. Ives, Macfarlane Anderson and others claim it can, while among those who answer in the negative are men well versed in theory if not in practice. The writer, while making experiments in defense of an assertion he had made, incidentally proved to his own satisfaction that some makes of ordinary plates possess orthochromatic properties to quite a pronounced degree, and has also been led to believe that all ordinary plates possess this quality to a greater or less extent.

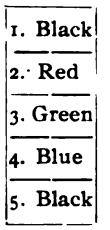


DIAGRAM OF SCREEN.

The failure of others to obtain similar results can, without doubt, be attributed to one or more of the following reasons: First. To using a plate having very weak orthochromatic properties; second, to using too light a screen or an unsuitable screen; third, to too short an exposure.

The Plate.—Why one make of plate shows stronger orthochromatic properties than another we will not discuss at length. It may be due to the method of making the emulsion or to the relative proportions of silver bromide and iodide in the film. That a film containing a large proportion of silver iodide is not as susceptible to the sensitizing influence of the dyes ordinarily used to impart orthochromatic properties is a well-known fact.

The Screen and Exposure.—For the sake of clearness in the following we will assume the spectrum to be divided, according to the old theory, into seven primary colors.

The sensitiveness of an orthochromatic plate to the yellow and green rays of the spectrum is so great that their value is often apparent without the aid of a medium to absorb the blue indigo, violet, and ultra violet.

With an ordinary plate whose sensitiveness to the red end of the spectrum is so weak compared with that of the violet end, a screen to absorb a portion of the rays of the violet end and thus to equalize the difference, is an absolute necessity, and, other things being equal, the darker the screen, the longer the exposure and the more pronounced the effect.

Mr. Ives has shown that a visual or photo-spectroscopic test of a screen is not always reliable, and that a practical test is the only satisfactory method. A consideration of the reproductions shown herewith of photographs made on an ordinary Seed 26 x 4 plate will more clearly explain the facts. The subject is a color plate in H. W. Vogel's *Handbuch der Photographie.*

FIG. 323.

No. 1, Without a Screen.—This shows the yellows and greens too dark while the ultramarine blue is nearly as light as the pink.

No. 6, Aurantia (single)—This was photographed through a screen made by coating thin mirror plate glass twice with the following colored collodion:

Aurantia	0.3 grammes
Warm alcohol	25. c.c.
Collodion (2 per cent.)	50. c.c.

This prints shows the yellows and greens lighter and the blues darker than in No. 1.

No. 13, Aurantia (double)—This was taken through two screens like No. 6 placed face to face. It gives a nearly perfect reproduction of the relative brightness of the different colors with the exception, perhaps, of the red being a little too dark. Comparison of this with No. 6 shows that even with a dye possessing a power of absorbing the so-called actinic rays, a sufficient body must be used to obtain good results.

No. 8, Naphthol Yellow (single).—A 3¼ x 3¼ piece of mirror plate was leveled and coated as thick as possible with a warm solution of

Naphthol yellow	0.5 grammes
Hard gelatine	10. grammes
Water	200. c.c.

Reasoning from analogy, one would say that if, as in No. 13, two screens were used, a considerably better result would be obtained, but experience has proved otherwise. Two screens while increasing the exposure considerably, gave but a slight improvement.

No. 14, Chrysoidine (double).—This reproduction is shown in order to illustrate the unreliability of the ordinary pocket spectroscope as a test for a suitable screen dye. Judging from an inspection with a pocket spectroscope this screen should give as good, if not better, results than No. 13, but a comparison of the two plates will show it that gives a more false rendering than even No. 1 (without a screen).

The following is the formula used:

Chrysoidine	.5 grammes
Alcohol	50. c.c.
Ether	50. c.c.
Pyroxyline	2. grammes

Thin mirror plate glass was coated once with this and two screens were placed face to face. They allowed so little light to pass that it was difficult to focus. This shows that the suitability of a dye is of more importance than the quantity. If a single chrysoidine screen is used with the naphthol yellow screen with which No. 8 was made, very good results are obtained with a long exposure.

The lengthening of the exposure by the addition of the naphthol yellow screen to the chrysoidine screen seems to be out of proportion to the amount the image is darkened on the ground glass, which fact is explained by Mr. Ives' showing that the ultra violet rays play a more important part in the production of an ordinary negative than is generally supposed, and it is these rays which the naphthol yellow screen absorbs, but which are allowed to pass by the chrysoidine screen, although the latter absorbs more of the visual rays.

Too short an exposure was mentioned as the rock upon which explorers were apt to strike and proclaim that there was no free channel. That one could err on this point is easy to be seen, for while with an orthochromatic plate the use of the double aurantia screen would lengthen the exposure from 20 to 30 times, I should judge, I found that with an ordinary plate and a bright sunlit landscape, this screen increased the exposure at least one thousand times. This was accomplished by exposing for minutes instead of seconds and using the largest stop allowable.

Of course such an exposure would restrict the use of an ordinary plate with a color screen to the photographing of distant views and to inanimate or practically inanimate objects.

ORTHOCHROMATIC OR ISOCHROMATIC PROCESS.—A process of obtaining photographic images of colored objects in true relative tone values. To obtain this, by counteracting the opposite effect that colors have upon the photographic plate to that upon the retina of the eye certain dyes are used.

The facts are these*, that when certain fugitive dyes absorb in a part of the spectrum to which the silver salt is insensitive, or only slightly sensitive, the rays absorbed produce an action on the silver salt in contact with it, either producing sensitiveness or increasing the sensitiveness. If the silver salt combines with the dye the action is readily explained by the ordinary theory, whilst if it does not the dye itself appears to undergo alteration, and to become, as it were, a developer, reducing a small portion of silver salt, on which subsequent development takes place.

The dyes generally used in practice are those known as erythrosine, rose bengal, or eosine, usually with an alkali as ammonia. There are two methods of applying the dye to the plate. It may be added to the gelatine emulsion before coating, and orthochromatic or isochromatic plates then prepared are sold commercially, or the plate may be laid in a bath of the dye.

In working with orthochromatized plates every precaution must be taken to prevent fog, as it should be remembered that these plates are sensitive to the yellow or red light. The very deepest ruby should be used, and the plates covered up as often as possible.

A plate should be chosen with an emulsion containing little or no iodide.† This is first bathed for two minutes in a solution of—

Liquor ammonia	1 part.
Water	100 parts.

Then without any previous washing it is immersed in—

Dye (eosine‡ or erythrosine)	1 part.
Water	10,000 parts.
Ammonia	100 parts.
Erythrosine or eosine††	1 part.
Water	1,000 part.

This is kept for a considerable time in the dark

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*Abney's "Instruction in Photography." † Burton and Pringle's "Processes of Pure Photography."

‡ It must be mentioned that a patent was secured by Messrs. Tailfer and Clayton in 1883 for the preparation of orthochromatic plates by means of an ammoniacal solution of eosine, and that a firm (Edwards & Co.) holds the rights for the manufacture in this conntry.

The ammonia solution may be a 10 per cent. one. Then take—

Dye solution (as above)	1 part.
Ammonia (10 per cent.)	1 part.
Water	8 parts.

Ives's process of orthochromatic photography is as follows :—

In four ounces of absolute alcohol dissolve one grain of erythrosine or cyanine, soak the gelatino-bromide plate in this for a minute, allow it to dry, and wash for a short time in a stream of running water. Dry and use. No alkali is necessary. Cyanine renders the plates so sensitive to red, however that all subsequent operations must be done as far as possible in total darkness.

Captain Abney recently found that color sensitiveness can be given to a plate by coating it with either varnish or collodion in which various sensitive dyes are dissolved. If erythrosine is to be used, varnish is stained to such an extent that when flowed over the film it shows a very light stain of dye. After exposure the plate is soaked in two or three changes of methylated spirit to remove the varnish, and after washing, development takes place in the ordinary manner. Any slight trace of varnish that may be seen, at once disappears if the plate be varnished as is usually done. If collodion be used the film must be first softened by alcohol to which a little ether has been added. After washing, development may proceed. Dyes which are not soluble in water can be made effective on gelatine plates by this method, and are certainly useful* Ives has also introduced a similar process, using chlorophyll as the sensitiser.

The following are some of the best known methods of rendering gelatino-bromide dry plates orthochromatic by bathing :—

SCHUMANN'S CYANINE BATH.

Distilled water	200 parts.
Alcohol	10 parts.
Ammonia	4 parts.
Alcoholic solution of cyanine 1 in 500	10 parts.

MALLMANN AND SCOLIK ERYTHROSINE BATH.

Water	200 parts.
Ammonia	2 parts.

Soak the plate for two minutes.

COLOR BATH.

Erythrosine solution, 1 in 1,000	25 parts.
Ammonia	4 parts.
Water	175 parts.

The plate must not remain longer than one and a quarter minutes.

CHINOLINE BATH.

Alcohol	500 parts.
Chinoline red	1 parts.

To which are added 50 parts of a solution of

Alcohol	500 parts.
Chinoline blue (cyanine)	1 part.

OBERNETTER'S METHOD WITH NITRATE OF SILVER.

Distilled water	480 parts.
Silver nitrate	1·25 parts.
Ammonium carbonate	5 parts.
Erythrosine solution (1 in 500)	35 parts.
Liquid ammonia	4 parts.

Bathe the plate for about 3 minutes in

Ammonia	2 parts.
Water	200 parts.

And, without washing, flow the sensitising solution twice over the plate and dry in the dark cupboard.

ORTHOCHROMATIC SCREEN.—All orthochromatic plates prepared by any of the methods at present known still remain far too sensitive to the blue and violet rays. It therefore becomes necessary to interpose between the object and the plate a yellow transparent screen which has the power of cutting off a certain portion of the blue and violet rays, and leaves the less refrangible with a relative degree of intensity and chemical actinicity more correctly corresponding with the relative action of the eye. Referring to the use and abuse of the orthochromatic screen,

* It must be noted that there are a great variety of eosines on the market, some of which are very inferior as color sensitisers. Erythrosine is much safer. Pure erythrosine should exhibit no fluorescence.

†Abney.

Professor Bothamley, who is an acknowledged authority on this subject, says:* "It is obvious that any variation in the tint or thickness of the screen will affect the proportion of blue and violet cut off, and hence will determine the relative activities of the various rays after they have passed through it. From an optical point of view, it is desirable to keep the screen as thin as possible, but the depth of tint of the screen admits of very considerable variation. As the depth of the tint of the screen increases, the proportion of blue and violet cut off increases proportionally, and the relative action of the less refrangible rays on the plate, or in other words, the relative brightness with which green, yellow, orange, and red objects are rendered increases at the same rate. It is obvious, therefore, that it is easy to make a screen so intense that far too large a proportion of blue and violet is cut off; blue and violet objects will then be too dark, and green, yellow, and orange objects too light. In other words, the resulting photograph will be as incorrect in one direction as the ordinary photograph is in the other. In landscape work a screen too deep in tint causes loss of atmosphere, and with erythrosine plates under these conditions the grass and all other yellowish green objects come out much too light. For landscapes the proper tint of screen is pale lemon-yellow; for paintings and similar subjects the depth of screen required is usually greater, and is determined by circumstances.

"The great advantage of the screen in landscape work is that it prevents the failure, or, at any rate, want of complete success, which often results from the presence of a slight blue haze. The details in the distance, which so greatly increase the beauty of many landscapes, are rendered much more satisfactorily, and the more correct values obtained produce a roundness of the foliage, a transparency in the water, and a separation of the various planes of the picture which is rarely, if ever, attained in any other way. This kind of effect is easily seen by looking at any ordinary view with the naked eye and then through a piece of yellow glass; the increased roundness of the objects and the separation of the planes is very striking.

"It has been claimed as an advantage for commercial orthochromatic plates that they can be used without a screen, which, of course, is true, but the results obtained are not such as to lead anyone to be enthusiastic about them. It seems as if an attempt were to be made to set up as the ideal of orthochromatic photography a plate which requires no screen. Given that the plate corresponded in sensitiveness with the human eye, that ideal would be realized, but we are some distance from realization at present, so far as gelatine plates are concerned. Moreover, it seems that the use of a screen, with the possibility of varying it to suit the work in hand, or the result which it is desired to obtain, places in the hands of the artistic photographer a power which he would be unwise to cast aside."

Carbutt, in his instructions for using his orthochromatic plates, recommends the following method of preparing a suitable color-screen:

"Extract the coloring matter from one ounce powdered turmeric in eight ounces alcohol by digestion and frequent shaking for a couple of days, then allow to settle. To two ounces sulphuric ether add 20 grains negative cotton and two ounces tincture of turmeric; shake until dissolved, and allow to settle; then coat the piece of thin plate glass, and, when dry, cement another piece of same clear glass over it with Canada balsam; allow to set for a day or two. The object of using the cemented glasses is that there will be less disturbance of the image caused then when a single glass is used. The color screen can be used either in front or at the back of lens, or placed next the diaphragm, and should be in position when focusing, and when not in use preserved in a box from the light, otherwise the color will soon bleach out.

"A very effective color-screen and diaphragm combined can be made by dusting the surface of a piece of glass with French chalk, removing the surplus with camel-hair brush, flow with the turmeric collodion, and allowed to dry. Cut from a thin black card a pattern of the diaphragm to be used, smear a thin coat of gum on one side, and lay it down on the collodionized glass, rub down to insure contact, place between leaves of a book until dry, then remove card diaphragm from the glass and with it the color-screen.

Professor Vogel recommends the following:

Collodionize a thin plate with

Normal collodion 1¼%	100 parts
Aurantia	0.4 parts

For landscape work 0.2 to 0.3 of aurantia will be found sufficient. The plate thus prepared can be placed either before or behind the lens.

Col. Waterhouse is of opinion that the best screens for orthochromatic work are made of clear thin talc or mica, coated with a cold drying crystal varnish made with benzole and sandarac or dammar colored with annatto or turmeric. Most of the yellow "coal tar" dyes are unfortunately insoluble in benzole. Varnish is far more structureless than collodion.

His formula is:

Turmeric varnish	2 parts
Annatto	1 part
Kamala	1 part

* Photographic Convention, 1889.

The turmeric varnish has a greenish tinge, the annatto a reddish tint, and the kamala (made from the powder obtained from *rottlera tinctoria*) a neutral yellow. By varying the proportions different tints are obtained.

The real use of a color-screen is to cut off the blue and violet rays, or at least a portion of them. With the orthochromatic plate this is also done, although to a much milder degree sufficient, however, for all ordinary purposes, either in landscape or portrait photography.

An orthochromatic plate is one made more sensitive to the yellow and red rays, and at the same time nearly as sensitive to the blue and violet. It is this fact that is the cause of its sometimes happening that an orthochromatic plate will give the same effect, apparently, as an ordinary one. Where there is no preponderance of the colors to which the former is more sensitive no apparent difference may be detected. Thus it often happens that an orthochromatic plate will in the middle of the day be slower than an ordinary one, but as the sun goes down the light becomes yellower, with perhaps a slight tinge of red, and the relative speed of the orthochromatic plate becomes greater and greater until it becomes faster by a good deal than the ordinary one. Indeed, it has often been found possible to make an exposure with an orthochromatic plate so late in the day that an ordinary plate would be useless.

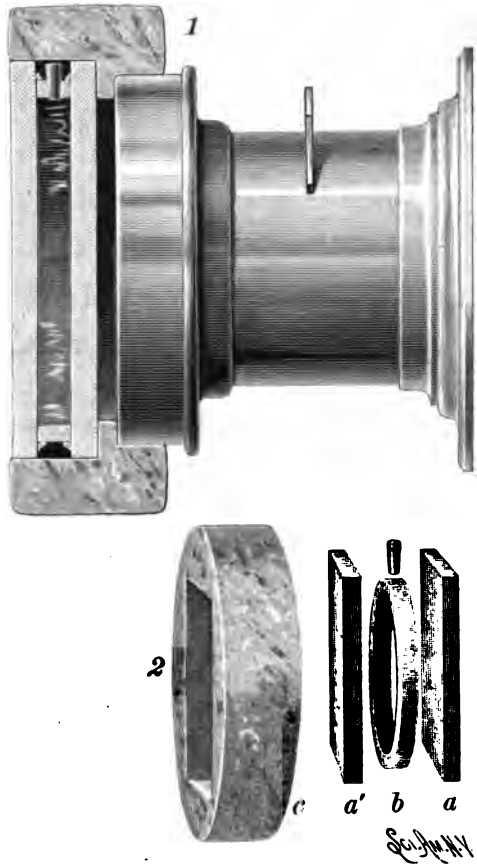

FIG. 324. BICHROMATE CELL FITTED TO LENS.

We might here consider the question of the advisability of using a screen for landscape work and it might be answered in this way: When photographing a view containing a large proportion of blue and violet light, and where, as we have said before, it happens that the effect is the same in the two kinds of plates, a colored screen is a decided advantage, but in certain other cases, that is to say, when the sun was low, or the light of a yellow color, a screen would not only be useless but absolutely disadvantageous. The light itself acts as the screen dispensing with its use in the same manner as in copying oil paintings by a yellow light, where a screen is also dispensed with. It is obvious, therefore, that the use of a screen in photographing landscapes must be left to the judgment of the photographer. It may be said, however, that it is very rarely necessary, and in almost every case an orthochromatic plate used alone will, by its increased sensibility to yellow or red, give a far better effect and a more truthful color rendering than an ordinary plate, and this, of course, is more and more apparent the larger the amount of yellow that is included in the picture. Thus, for instance, the effect is most apparent in photographing a woodland scene in autumn when the leaves are turning yellow, and in this case of affairs a screen is absolutely unnecessary. Indeed, its only effect would be to increase the exposure necessary. As we said before, the only occasion for the use of a color screen in landscape photography is when the violet and blue rays have so pronounced an action upon the sensitive film that their representation in monochrome is out of all proportion to the effect of the color value as apparent to the eye. Thus, for instance, in cloud effects upon a blue sky the blue has an action on the film quite as powerful as the white clouds, and consequently there is no contrast visible in the finished picture.

In copying colored pictures, oil paintings, etc., a color screen is almost invariably employed, uuless the picture is lighted by a yellow light, which has practically the same effect.

What is the best form of color screen is another question that requires consideration. It is often imagined that any piece of glass coated with a yellow dye in gelatine or collodion will answer the purpose. This is by no means the case. If a glass be used it must be optically plane on both sides. Ordinary glass is liable to be curved either over the whole or in parts, and the effect of such a condition would of course be to throw those parts of the image out of focus.

It would seem to be immaterial where the screen is placed, either before or behind the lens. Many, however, prefer the latter position.

Some years ago we used color screens made of dyed collodion film, pasted over the diaphragm aperture and used between the glasses of the lens. This is, we believe, a common practice in Germany. Others, again, prefer to place the screen in contact with the plate itself. For landscape work the color should be of a very pale yellow. If too strong it is liable to give an exaggerated effect; that is to say, the distant parts of a landscape would appear too sharply

defined; they would lose all effect of distance imparted to them by the mistiness that leads aerial perspective to the view.

An arrangement employed at the Weather Bureau at Washington by Mr. A. J. Henry is the following—given in a recent issue of *The Scientific American*.* The photograph is made through a screen. The one found most effective is that formed of a saturated solution of bichromate of potash inclosed in a plate glass cell having parallel sides. The construction of this cell is shown in the second engraving, in which *a a'* are squares of plate glass, and *b* is a ring cut from a glass tube and ground to render its edges parallel and smooth. One side of the ring is perforated and furnished with a stopper. The ring is cemented between the two glass plates with balsam of fir or other suitable cement. The saturated solution of bichromate of potash is introduced through the perforation, and the cell thus made is inserted in a piece of cork, *c*, which fits over the collar of the camera lens. The proper thickness for the cell is shown in the engraving (Fig. 324); the diameter will of course vary with the size and the angle of the lens. The exposure required for the negative is usually about four seconds.

ORTHOGRAPHIC.—A name given to a certain class of photographic lenses.

ORTHOHYDROXYBENZOIC ACID.—See **Salicylic Acid.**

ORTHOSCOPIC.—A name given to a certain class of photographic lenses.

OSMIUM (symbol, Os., atomic weight, 199.2).—A tetrad metallic element discovered by Tennant in 1804.

Osmium forms three chlorides—osmious chloride $OsCl_2$, osmioso-osmic chloride $OsCl_3$, and osmic chloride, $OsCl_4$—which are all produced by the action of chlorine gas on osmium.

OSMIUM TONING.—Osmium has often been recommended in toning, but is rarely used on account of its costliness. The formula will be found under **Toning Baths.**

OSMOSIS.—A peculiar phenomenon noticeable in mixing dissimilar substances through a porous diaphragm (see **Dialyser**) due to the attraction which the liquids have for each other. If, for instance, water and alcohol be separated by a permeable medium the water passes into the alcohol, but only a small quantity of the alcohol will have passed into the water. If a colloidal substance is placed on one side, and water on the other, only the latter passes through.

OUNCE.—A unit of weight. In troy weight the ounce is the twelfth part of a pound, and contains twenty pennyweights of twenty-four grains. In avoirdupois weight the ounce is the sixteenth part of a pound, and is equivalent to 437½ grains troy.

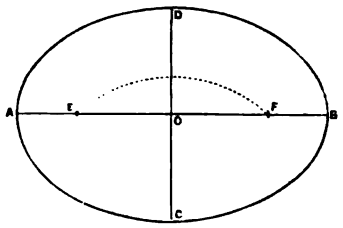

FIG. 325.

OVAL.—Having the shape or figure of the outline of an egg. Elliptical is often used for "oval," but oval means "egg-shaped," *i.e.*, one end larger than the other, while an ellipse has both ends alike.

A simple method of tracing an ellipse is the following:† On a piece of stout paper draw a line A B (Fig 325), making it the *extreme* width of the oval required. Bisect it at O and draw D O C at right angles to A B. Make O C equal to half the smallest diameter of the ellipse. With the center C and the distance O B, draw an arc of a circle, cutting A B in E and F. Place the paper on a flat board, and at E and F fiix two drawing pins. Take a piece of thread and knot it together in such a manner that half its length is equal to A F. Place the thread round the two pins at E and F, and stretch it out to tightness by the point of a lead pencil. Move the pencil, guided by the cotton, taking care to keep it upright. The resulting figure will be an ellipse.

OVALBUMEN.—A term applied to albumen obtained from eggs in contradistinction to that known as seralbumen, or the albumen of the blood.

OVER DEVELOPMENT.—Over development is caused by the developing solution having been too strongly concentrated, or to its action having been allowed to continue for too long a period. To judge correctly the exact time to remove the plate from the developer is one of the chief difficulties to be surmounted in learning the art of developing. Allowance must always be made for considerable loss in intensity in the fixing operation, so that the usual error made by the beginner is in under—rather than over—developing. The amount of density lost in the fixing bath depends partly upon the quality of the developer and partly upon the strength of the hypo-sulphite solution used. The usual method of treating over-developed negatives is to reduce their intensity by means of a reducing agent. See **Reducing.**

* We are indebted to the kindness of the publishers of this excellent magazine for the loan of cut illustrating the apparatus.

† Art and Practice of Silver Printing.

Over-developed negatives may, according to Herr Jandaurek, be restored as follows:—A stock solution is made of 10 grammes of sulphate of copper (blue vitriol) and 30 grammes of common salt in 120 c.c. distilled water. To every part of the stock solution add ten parts of water. Lay the washed negative in this diluted solution, gently rocking it for several minutes, until both by looking down upon it and looking through it its surface appears to be covered with a dense white precipitate. Take out the negative, rinse it well with water, and then lay it in a diluted solution of liquid ammonia, about 6 to 10 of water to one part of ammonia, until the negative is sufficiently reduced. The rapidity of the reduction depends upon the strength of the ammonia, which should always be added fresh.

OVER-EXPOSURE.—A term applied if the exposure of the sensitive surface be prolonged farther than is required to impress it with all the detail, even in the darkest parts. The effect produced is seen in the developing when the image rapidly makes its appearance, and before sufficient density can be obtained it appears fogged. The resulting negative is exceedingly thin, generally full of detail, but wanting in contrast and brilliancy. By very careful manipulation in development the effects of over-exposure can be partly corrected.

If the plate is known to be over-exposed it can sometimes be saved by immersing for two or three minutes in diluted chlorine water before developing.

Considerable over-exposure produces solarization and reversal of the image (*q.v.*)

OXALATE-DEVELOPER.—See **Developer.**

OXALATE OF AMMONIUM.—See **Ammonium Oxalate.**

OXALATE OF IRON.—See **Ferrous Oxalate.**

OXALATE OF POTASH.—See **Potassium Oxalate.**

OXALATES; TESTS FOR.—Solutions containing these salts give—with barium nitrate a white precipitate soluble in hydrochloric acid and with silver nitrate a white precipitate soluble in nitric acid.

OXALIC ACID (Formula, $H_2 C_2 O_4 + 2H_2 O$; molecular weight, 126).—A white crystalline body frequently found in plants, and which may be produced by the oxidation of sugar and other organic substances, or by acting on starch, sugar, or cellulose with nitric acid, or fusion with caustic alkali.

It is produced commercially by fusing sawdust with a mixture of soda and potash at a temperature of 204° C., decomposing the oxalate with lime, and the lime salt with sulphuric acid, and afterwards recrystallizing. It takes the form of colorless transparent prisms soluble in eight parts of water at 15° C, and in its own weight of boiling water. It forms a powerfully acid solution. It unites with bases, forming neutral and acid salts, and is highly poisonous. Half an ounce is known to have been fatal.

Oxalic acid sometimes contains traces of sulphuric acid. This may be detected by the addition of barium nitrate, and afterwards hydrochloric acid in excess. If sulphuric acid be present a portion of the precipitate will remain undissolved. It is employed in the preparation of ferric oxalate.

OXALIC ETHER (Formula, $C_2 O_4 (C_2 H_5)_2$).—Neutral oxalate of ethyl prepared by the distillation of a mixture of four parts binoxalate of potash, five parts oil of vitriol, and four parts of strong alcohol. The distillate is then washed in water. It forms a colorless oily liquid, with an agreeable aromatic odor, and a specific gravity of 1·09. It is only slightly soluble in water.

OXFORD MOUNT.—See **Mount.**

OXGALL (also known as *oxbile*). The fresh bile of the ox purified and evaporated to the necessary consistency. It is used in painting with water colors, and is especially serviceable in causing the colors to adhere to the surface of albumen paper photographs. It is soluble in water and methylated spirit. The surface of the print should be rubbed over with a small quantity of an oxgall solution previous to applying the colors.

OXIDATION.—The chemical change which causes the formation of oxides, and which is brought about by the action of oxygen acids, water, or free oxygen. Refer to developer and method of keeping.

OXIDE.—The product of the combination of oxygen, with a metal or metalloid. When substances are burnt, they are not lost, but have simply changed into new bodies by combination with the oxygen of the air. If it be a metal the product is an "oxide" or "base" which, if soluble in water, has properties the reverse of acid.

OXIDE OF CALCIUM.—See **Calcium Oxide.**

OXIDE OF COPPER.—See **Copper Oxide.**

OXIDE OF MANGANESE.—See **Manganese Binoxide.**

OXIDE OF SILVER.—See **Silver Oxide.**

OXYACID.—Acids which contain oxygen, such as sulphuric acid, which has for its formula H_2SO_4.

OXYAMMONIUM CHLORIDE.—See **Hydroxylamine Hydrochloride.**

OXYCALCIUM LIGHT.—See **Oxyhydrogen Light.**

OXYETHER.—A mixture of oxygen and ether. This is used in a form of oxyhydrogen light for the lantern.

OXYGEN (Symbol, O; atomic weight, 16).—The most abundant element. It is present in the air we breathe, it forms $\frac{8}{9}$ths (by weight) of water, and is present, to a great extent, in the solid part of the earth.

Oxygen can only be obtained from something that contains it. For this purpose chlorate of potassium is the most convenient, as by merely applying heat it separates into potassium chloride and oxygen, thus—

$$KClO_3 = KCl + 3O$$

One molecule of the salt yielding three atoms of oxygen gas.

In the preparation of oxygen for commercial purposes, the potassium chlorate with about half its weight of black oxide of manganese is used.

In the following description* will be found a simple method of manufacturing oxygen gas on a small scale:

Oxygen gas is obtained by subjecting to heat in a copper retort a mixture of one part of black oxide of manganese with four parts of chlorate of potash. The exact proportions are not arbitrary. The gas comes from the chlorate, and the office of the manganese is only to separate the particles of chlorate, that the gas may generate evenly and be more readily controlled.

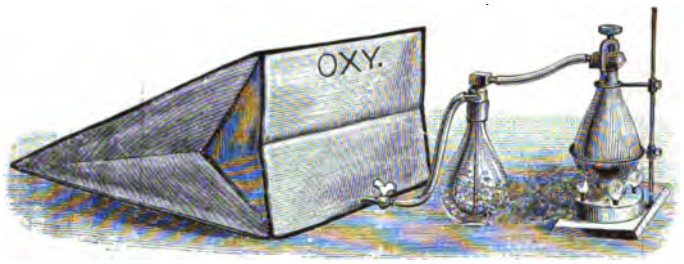

FIG. 326. RUBBER GAS BAG. WASH BOTTLE. COPPER RETORT, STAND & LAMP.

A pound of chlorate should yield about 4½ cubic feet of gas.

A test of the chemical should be made before using. This may be done by putting a little in an iron dish or spoon and holding over a lamp. If the chemicals are good they will melt, dry up and leave a gray residuum, but if not good they will flash up, in which case they would not be safe to use.

The copper retort must be clean and dry. Put into it sixteen (16) or eighteen (18) ounces chlorate of potash and about one-quarter as much black oxide of manganese first thoroughly mixed. Close the retort tightly and attach the rubber hose to the pipe on top of retort. The other end of the rubber hose goes on the nozzle connecting the tube running inside one of the purifying bottles. From the other nozzle of the bottle another piece of rubber hose connects the bottle with the gas bag.

The purifying bottle must contain water enough to cover about an inch of the lower end of the brass tube. The gas passes from the retort through the rubber hose and the brass tube into the water, which washes it as it passes through; it is then carried by its own force out at the other nozzle into the bag. Before making all the connections, blow through the tubes to see if they are clear.

After connecting retort and wash bottle place the lighted lamp under the retort, turning the light well up. In a few minutes the water in the bottle will bubble as the gas generates. Allow it to escape for a while. Test its strength by holding before the open orifice a piece of charred wood with remaining sparks of fire; when strong enough to fan these into a flame, the rubber hose connecting with the gas bags may be attached and the gas allowed to flow into the bag. Be sure the cock on the gas bag is opened to allow the gas to enter.

Very violent agitation in the bottle should be checked by removal of heat from retort.

Action will go on some time after lamp is removed and perhaps long enough to fill the bag, but should it not, heat must again be applied to retort. A little care in regulating heat of retort will insure a regular flow of gas until the bag is full.

When the bag is full, disconnect rubber hose from bottle, close stop cock on the bag, disconnect bottle from retort and then remove the heat.

* This description is supplied by Messrs. J. B. Colt & Co., 16 Beekman Street, N. Y., who manufacture the apparatus depicted.

Cleanse the retort by a thorough washing with water until all black sediment is removed and then put it where it will dry completely, as there must be no moisture in it when gas is made.

Blow through pipes and hose and see that they are free from obstructions.

The apparatus used for the generation of one of the gases should never be used for the other, therefore it will be well to mark plainly the bag, bottle and connections with the name of gas for which they are first used.

The action of the manganese is not properly understood, but the evolution of the oxygen is rendered considerably more rapid even with a much lower temperature. Clean, coarse sand is equally efficacious.

The preparation of oxygen on a large scale by the Brin method is thus described:* The routine of the process begins with the pumping in of air from the atmosphere, which is passed into a large receiver containing caustic lime, and thence into a second and smaller receiver of caustic soda; the latter acting as a check on the former in the removal of moisture and carbonic acid from the air. The purified air is then passed into large pumps, where it undergoes slight compression, and finally passes through a chamber for filtering out solid particles, and a distributor placed on top of the furnace, into the retorts. The large furnaces are built at an angle with the horizontal, and contain on each side twelve inclined retorts, of cast iron, of six and a half inches internal diameter, one inch thick and about ten feet long. These hold between 2000 and 3000 pounds of barium in small lumps. A temperature of about 1300° Fahr. is obtained by the admission of primary and secondary air into a coke furnace, the carbonic oxide found being burnt into carbonic acid in the combustion chambers. By means of wall-holes in the sides of the furnaces one sees the retorts at a dull red heat. The heated barium abstracts the oxygen from the purified air, and the free nitrogen escapes up through an automatic valve, whence it passes out into the atmosphere. At the end of five minutes an automatic reversing gear reverses the working, a vacuum is created in the retorts, the air and impure oxygen in the connecting pipes are blown away, and the oxygen passes back through the pipes to a comparatively distant part of the works into the gasholder, which has a capacity of 2000 feet.

In another five minutes the reversing gear is again automatically converted, air passes into the purifiers, as before, thence to the pumps and retorts, and so on, for every five minutes of the day and night, Sundays as well as week days, all the year round. The maximum volume of gas capable of being drawn off can thus be seen to be very large. At the time of our visit only one of the furnaces and one set of retorts were at work. As showing the longevity of the barium oxide, the company are still using barium which was first employed in 1886, when the Brin syndicate started working the process. After a time the barium is prone to cohesion, when it has to be taken out and broken up.

From the moment when the air is pumped into the purifiers until the pure oxygen leaves the compressor the process is practically automatic, save and except such attention as even automatic machinery must have. Of special value in this, in that, when the air and impure oxygen are blown out of the pipes, the egress of atmospheric air is prevented. In atmospheric air there are, by weight 23.1 parts of oxygen to 76.9 of nitrogen, and by the Brin process about fifteen parts by weight of the oxygen are taken up by the barium monoxide.

OXYGENATE.—To unite or combine with oxygen.

OXYGENATED WATER.—See **Hydrogen Peroxide.**

OXYGENOUS.—Pertaining to or derived from oxygen.

OXYHYDROGEN.—A mixture of oxygen and hydrogen used in the limelight for the optical lantern.

OXYMEL PROCESS – An early process for keeping the collodion moist. Oxymel is a mixture of vinegar and honey, and collodion plates coated over with it were found to retain their good qualities several hours. The exposure was, however, considerably increased.

OXYPHENIC ACID.—See **Pyrocatechin.**

OZONE.—This is usually considered to be oxygen in an allotropic condition. It is nearly always present in the air, apparently as the result of electrical action. It can be produced by passing electric sparks into dry air, and also by placing sticks of clean phosphorus in a bottle of oxygen, and half covering them with water. It possesses a peculiar slightly metallic odor, and appears to possess all the properties of oxygen in an enhanced degree. It liberates iodine from potassium iodide. Schönbein, who discovered and named it, employed this re-action for detecting it in the atmosphere.

PACKFONG (Chinese).—A Chinese alloy known as white copper. It is composed of copper 40·4, zinc 25·4, and nickel 31·6. It is used sometimes for making mirrors or reflectors.

*The Lantern Record.

PACKING PLATES.—In packing sensitive dry plates every precaution must be taken in protecting them from the light and from mechanical injury and chemical change. Very many methods are employed; probably the use of grooved boxes or strips of cardboard folded so as to prevent the sensitive surfaces of the plates from touching, are the methods most generally adopted. A good plan is to take a long strip of perfectly pure tissue paper, and so fold it that it lies between every plate. By thus alternating the plates and paper the fear of breakage is reduced to *nil*. It is, however, absolutely essential that the paper be chemically pure. Gelatino-bromide films rapidly absorb impurities from materials in which they are wrapped, a chemical change is produced, and on developing a black mark is visible usually round the edges of the plate. The more rapid the dry plate the more sensitive it is to these changes.

When travelling aboad it is very difficult sometimes to restrain Custom House officials from opening and examining packages of dry plates, more especially if the tourist's knowledge of the language of the country is imperfect. In order to prevent this, therefore, the following labels have been compiled, and will be found to fairly cover the ground.

English.—Photographic dry plates, sensitive to light. Open only in a dark room or by a red light.

French.—Plaques séches photographiques. A ouvrir seulement avec eclairage couleur rubis. *Or*—Plaques photographiques sensibles. Tout detruites par l'exposition à la lumière. Prendre garde de n'ouvrir la boîte que dans une chambre parfaitement obscure.

German.—Photographische trockenplatten. Sehr lichtempfindlich. Werden ganz verdorben, wenn dem Lichte ausgesetzt. Müssen nur in absolut dunkelm Zimmer oder bei rothem Lichte geöffnet werden.

Italian.—Teme la luce. Lustre da seccare fotografiche. Da aprire solamente con illuminazione colore de rubino.

Spanish.—Las planchas fotográficas sensibles se inutilizan si se las expone al abrirlas, á la luz del dia, se pueden abrir sin peligro en una habitación enteramente oscura ó iluminada por luz roja.

Swedish.—Fotografiska plätar ma icke oppenas utom vid rodt Ljus. *Or*—Ljuskäushga fotografiska plätar, blivfa förstörda om de uttsätas för ljus. Fas derföre ej öppnas utom i ett absolut mörkt rum.

Norwegian.—Fotografiske plader maa ikke aabnes udem ved rodt Lys.

Portuguese.—Nao podem ser expostas á luz porque se enutilisam; podendo só ser abertas em camara, ou com.

PAD.—A soft piece of felt or other material used to place between the sensitive paper lying on the negative and the back of the printing frame to prevent breakage of the negative, and to ensure even and uniform contact between the sensitized paper and the negative film.

PAINTING PHOTOGRAPHS.—Photographs may be painted over either with oil or water colors. With the latter the silver print should be previously washed over with a solution of oxgall. The colors will then adhere more firmly. See **Colored Photographs, Oil Paintings,** &c.

PALLADIUM. (Symbol Pd; atomic weight, 105·7).—A tetrad metallic element usually found associated with gold and platinum, chiefly in South America. It is separated from the gold by fusing the alloy with silver* and boiling it with nitric acid, which leaves the gold undissolved. The silver is precipitated from the solution as chloride by adding sodium chloride, and metallic zinc is placed in the liquid which precipitates the palladium, lead, and copper as a black powder. This is dissolved in nitric acid, and the solution mixed with an excess of ammonia, which precipitates the lead oxide, leaving the copper and palladium in solution. On adding hydrochloric acid in slight excess a yellow precipitate of palladamine hydrochlorate is obtained, which when heated leaves metallic palladium.

Palladium has a sp. gr. of 11·5. It resembles platinum in malleability and ductility, but is more fusible, less dense, and has a more silvery appearance. The chloride has occasionally been recommended for toning.

PALLADIUM TONING.—Palladous chloride is used for this purpose. It may be obtained in crystals or in solution; the bath is made up of

Palladous chloride	1 grain.
Sodium sulphite	20 grains.
Water	10 ounces.

A silver print is first made upon plain salted paper. This is washed with clear water containing a little common salt, and afterwards in pure water. The print is then brushed over with the palladium solution as above. Some operators recommend that the solution be made slightly acid by the addition of a few drops of nitric acid. The picture is then fixed in hypo containing a few drops of ammonia added until the solution smells slightly of it. Each lot of prints should be fixed in a fresh bath. The results obtained are very similar to those toned with platinum. For

* Bloxham's Chemistry.

rough surface paper the black tone is very effective, the prints much resembling Indian ink drawings. Palladous chloride is very expensive, but the quantity used is small.

Another formula* is as follows :

Palladous chloride	1 gramme.
Chloride of sodium	1 gramme.
Distilled water	100 c. c.

If any difficulty is occasioned in solution or if a precipitate be formed, the liquid is slightly heated in a porcelain dish until the solution becomes clear. 10 c. c. of acetic acid and 400 c. c. of distilled water are then added. In toning a yellow tinge will sometimes appear in the prints, this can be removed by immersion in a 5 per cent. solution of ammonia.

PALLADOUS CHLORIDE (Formula, $PdCl^2$).—Prepared by acting on palladium with aqua regia and evaporating. The brown hydrated crystals obtained, if heated to redness, lose chlorine, leaving metallic palladium. In this respect it much resembles platinum as well as in the formation of double salts with the alkaline metals. It is used in the palladium toning process.

PANEL.—The style of a professional photograph, usually about 4 x 8½ inches.

PANEL LENS.—A lens constructed for making panel photographs. It has usually a diameter of about 3¼ to 4 inches, and a focal length of between 16 and 20 inches, the sitter being placed at from 14 to 16 feet from it.

PANORAMIC CAMERA. — A camera specially constructed as to enable photographs embodying a very large angle of view to be taken, usually upon a curved surface. The first camera of this kind was constructed by Mr. Martens, of Paris, in the year 1847, for cylindrical Daguerreotype plates. Then followed the camera of Sutton.† A cylindrical glass was employed, and the negative paper bent so as to press against it. Cylindrical collodion plates were also used, but this, of course, necessitated the use of curved printing frames. These plates were, of course, curved in the form corresponding to the rotation of the camera around the axis situated exactly below the center of the lens. If flat plates had been used it will be obvious that the upper horizontal lines of the image would be curved in an upward direction, and the lower ones in a downward. After Sutton's patent came the improvement of Dr. Liesegang, by which it was transformed into a simple rotating camera. A stout tripod carries a large polished table, fitted to which is a pivot or axis upon which the camera turns. The pivot is so adjusted as to fall into the same plane as the optical center of the lens. These cameras are made in two sizes for plates 19 by 9 and 23 by 11 inches. In front of the plate inside the camera a flexible band is fitted which has a narrow vertical slit through which only the middle rays of light pass. This slit is about a quarter of an inch wide, but widened out a little where the near foreground falls in order to secure a longer exposure for that portion of the picture, and thus impart greater uniformity to the tone of the negative. The two motions of the instrument, viz, that of the camera on its axis and the motion of the dark slide, supported on wheels, from right to left, are performed by an ingenious arrangement of horizontal cords and pulleys. After focusing, the operator has only to turn a handle to take in the wide scope of the horizon or a group arranged in a semicircle around the instrument. Any lens may be used provided its focus is in a range with the length of the camera.

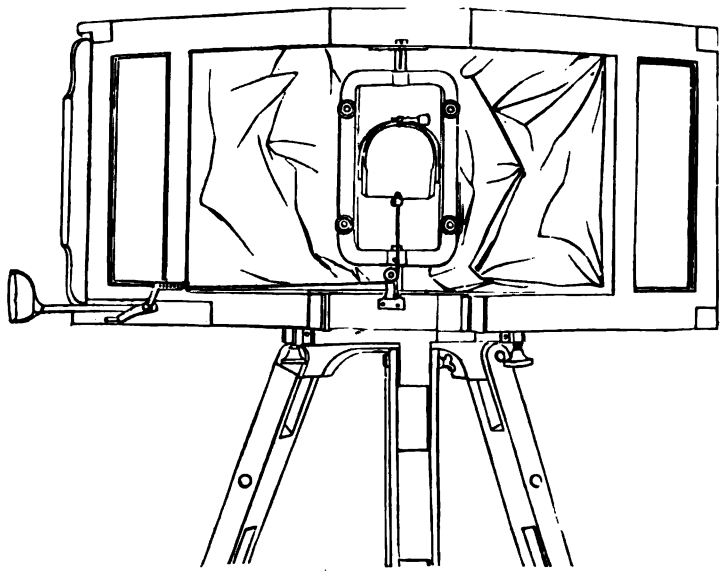

FIG. 327.

The latest form of panoramic camera is that shown in Fig. 327. Films are used, and these are placed in the curved holder. The light from the lens passes through a small slit, which runs along the sensitive film as the lens rotates. See also **Panoramic Photography, Cylindrograph.**

PANORAMIC LENS.—A lens constructed for making panoramic views. The first of this kind was invented and patented by Sutton in 1858. It was intended for photographing views, including an angle of 90 degrees or more upon spherical bowls or cylindrical glasses. See **Fluid Lens.**

* P. C. Duchochois.

† See Sutton's "Dictionary of Photography."

PANORAMIC PHOTOGRAPHY.—In making panoramic views a panoramic camera is usually employed. This is described under that heading. Panoramic views may also be made with an ordinary camera by taking two or three views and joining them together. For this purpose the screw of the tripod must be slightly loosened, so that the camera turns round easily. When the first view is made, objects on the extreme right hand side of the glass are noted, and the camera turned round on the screw until these objects appear on the extreme left. The second view is then made, and so on. In mounting the prints from the different negatives the greatest care must be taken to make the joints neatly, and to have the prints cut so that the images join together properly. When any difficulty is experienced in this it will be found a better plan to mount the pictures about a quarter to half an inch apart. This method is not quite so effective, but appears considerably better than a badly joined view.

It will be obvious that with all panoramic views the laws of perspective are violated to a considerable extent, and that an absolutely correct representation of the view is not given. Burton* in an article upon this subject gives a diagram (see Fig. 328), showing how the pictures must be arranged to be viewed correctly. In this it is supposed that five 12x10 pictures taken with 22 inch lens are cut down to 11 inches in length. In Sutton's camera curved plates were used, and prints made from these curved negatives were viewed flat. To obtain correct representation it would be necessary to view them curved in the same manner.

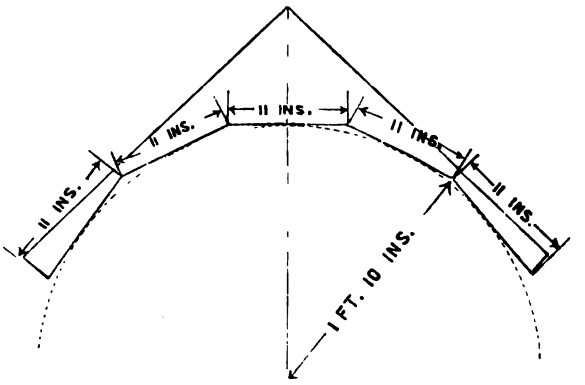

FIG. 328.

PANTASCOPIC CAMERA.—An instrument invented by J. R. Johnson for taking panoramic views, including an angular extent up to 360 degrees upon a flat plate with a common lens by means of mechanism or clockwork.

PAPER.—A material made in thin sheets from a pulp of rag esparto grass, straw, wood, and many other fibres. Over 500 different substances have been used for manufacture of paper; rags and esparto grass form the best materials, however.

A large number of different kinds of paper are now manufactured in this country. For most photographic purposes it is advisable to use perfectly pure paper. The best known are those manufactured at Rives and at Saxe; these papers have a very even body, and are quite free from chemical impurities.

Metal dust in paper will not be visible until the same be sensitized with silver nitrate when black spots will directly appear.

The quality of the paper has also a considerable effect upon the subsequent permanency of the photographic images made upon it. Many kinds contain a large quantity of sodium hyposulphite used as an antichlor. This should be carefully tested for.

The following tables of sizes of the different printing and writing papers will be found of use :—*

PRINTING PAPERS.

Description.	Broadside.	Long Folio.	Long Thirds.	Long Fourths.	Broad Folio.	Broad Thirds.
Double Super Royal	41 x 27½	41 x 13⅞	41 x 9⅛	41 x 6¾	27½ x 20½	27½ x 13⅝
Do. Royal	40 x 25	40 x 12½	40 x 8⅓	40 x 6¼	25 x 20	25 x 13⅓
Do. Demy	35 x 22½	35 x 11¼	35 x 7½	35 x 5⅝	22½ x 17½	22½ x 11⅝
Imperial	30 x 22	30 x 11	80 x 7⅓	30 x 5½	22 x 15	22 x 10
Double Crown	30 x 20	30 x 10	30 x 6⅔	30 x 5	20 x 15	20 x 10
Super Royal	28½ x 21½	28½ x 10¾	28½ x 7⅙	28½ x 5⅜	21⅓ x 14½	21⅓ x 9⅓
Double Foolscap	27 x 17	27 x 8½	27 x 5⅔	27 x 4¼	17 x 13⅔	17 x 9
Royal	25 x 20	25 x 10	25 x 6⅔	25 x 5	20 x 12½	20 x 8⅓
Medium	24 x 19	24 x 9½	24 x 6⅓	24 x 4½	19 x 12	19 x 8
Demy	22½ x 18	22½ x 9	22½ x 6	22¼ x 4½	18 x 11⅓	18 x 7 5/8
Crown	20 x 15	20 x 7½	20 x 5	20 x 3¾	15 x 10	15 x 6⅔
Foolscap	17 x 13½	17 x 6¾	17 x 4½	17 x 3⅜	13½ x 8½	13½ x 5⅔

* Photographic Times, February 24, 1893.

WRITING PAPERS.

Description.	Broad-side.	Long Folio.	Long Thirds.	Long Fourths.	Broad Folio.	Broad Thirds.
Imperial	30 x 22	30 x 11	30 x 7⅓	30 x 5½	22 x 15	22 x 10
Su. Royal H. M. B. L.	27 x 19½	27 x 9⅝	27 x 6 5/8	27 x 4 1/16	19½ x 13½	19½ x 9
Royal H. M. B. L	24½ x 19½	24½ x 9⅝	24½ x 6½	24½ x 4⅞	19½ x 12⅛	19½ x 8 1/16
Do. H. M.	24 x 19½	24 x 9⅝	24 x 6½	24 x 4⅞	19½ x 12	19½ x 8
Medium H. M. B. L	22 x 17½	22 x 8⅝	22 x 5¾	22 x 4 5/16	17½ x 11	17½ x 7⅛
Do. M. M. B. L.	22⅛ x 17⅜	22⅛ x 8⅞	22⅛ x 5 1/16	22⅛ x 4 7/16	17⅜ x 11¼	17⅜ x 7⅛
Demy H. M. B. L	20 x 15⅝	20 x 7⅞	20 x 5¼	20 x 3 15/16	15⅝ x 10	15⅝ x 6⅜
Do. M. M. B L	20¼ x 15½	20¼ x 7⅝	20¼ x 5⅛	20¼ x 3 13/16	15⅛ x 10⅛	15½ x 6¼
D'ble Foolscap M. M.	27 x 17	27 x 8½	27 x 5⅝	27 x 4¼	17 x 13½	17 x 9
Foolscap H. M. B. L.	17 x 13⅜	17 x 6⅝	17 x 4⅜	17 x 3⅜	13⅜ x 8½	13⅜ x 5⅝
Do. M. M.	16½ x 13¼	16½ x 6⅝	16½ x 4 5/16	16½ x 3 5/16	13¼ x 8¼	13¼ x 5⅛

PRINTING PAPERS.

Long Quarto.	Broad Quarto.	Long Octavo.	Common Octavo.	Long 12mo.	Common 12mo.	16mo.	32mo.
27½ x 10¼	20½ x 13⅜	20½ x 6⅞	13⅜ x 10¼	13¾ x 6⅝	13⅜ x 6⅞	10¼ x 6⅞	6⅞ x 5⅛
25 x 10	20 x 12½	10 x 6½	12½ x 10	12½ x 6⅜	13⅛ x 6½	10 x 6½	6½ x 5
22½ x 8¾	17½ x 11¼	17½ x 5⅝	11¼ x 8¾	11¼ x 5⅝	11⅜ x 5⅝	8¾ x 5⅝	5⅝ x 4⅜
22 x 7½	15 x 11	15 x 5½	11 x 7⅛	11 x 5	10 x 5½	7½ x 5⅛	5⅛ x 3⅝
20 x 7⅛	15 x 10	15 x 5	10 x 7⅛	10 x 5	10 x 5	7⅛ x 5	5 x 3⅝
21⅜ x 7⅛	14¼ x 10⅜	14¼ x 5⅜	10⅜ x 7⅛	10⅜ x 4⅜	9½ x 5⅜	7⅛ x 5⅜	5⅜ x 3 9/16
17 x 6⅜	13⅜ x 8½	13⅜ x 4¼	8½ x 6⅜	8½ x 4½	9 x 4¼	6⅜ x 4¼	4¼ x 3⅛
20 x 6½	12½ x 10	12½ x 5	20 x 6½	10 x 4⅛	8½ x 5	6½ x 5	5 x 3⅛
19 x 6	12 x 9⅛	12 x 4⅜	9⅛ x 6	9⅛ x 4	8 x 4⅜	6 x 4⅜	4⅜ x 3
18 x 5 9/16	11¼ x 9	11¼ x 4½	9 x 5 9/16	9 x 3 17/32	7 5/16 x 4½	5 9/16 x 4½	4½ x 2 25/32
15 x 5	10 x 7⅛	10 x 3⅝	7⅛ x 5	7⅛ x 3⅛	6⅝ x 3⅝	5 x 3⅝	3⅝ x 2½
13½ x 4¼	8½ x 6⅜	8½ x 3⅜	6⅜ x 4¼	6⅜ x 2⅞	5⅜ x 3⅜	4¼ x 3⅜	3⅜ x 2⅛

WRITING PAPERS.

Long Quarto.	Broad Quarto.	Long Octavo.	Common Octavo.	Long 12mo.	Common 12mo.	16mo.	32mo.
22 x 7½	15 x 11	15 x 5½	11 x 7½	11 x 5	10 x 5½	7½ x 5½	5½ x 3⅝
19½ x 6⅝	13½ x 9⅝	13½ x 4 13/16	9⅝ x 6⅝	9⅝ x 4½	9 x 4 13/16	6⅝ x 4 13/16	4 13/16 x 3⅜
19½ x 6 1/16	12⅝ x 9½	12⅝ x 4⅞	9½ x 6 1/16	9½ x 4 1/32	8 1/16 x 4⅞	6 1/16 x 4⅞	4⅞ x 3 1/16
19½ x 6	12 x 9½	12 x 4⅞	9½ x 6	9⅝ x 4	8 x 4⅞	6 x 4⅞	4⅞ x 3
17½ x 5½	11 x 8⅝	11 x 4 15/16	8⅝ x 5⅛	8⅝ x 3⅝	7½ x 4 15/16	5½ x 4 15/16	4 15/16 x 2½
17⅝ x 5⅝	11¼ x 8⅞	11¼ x 4 7/16	8⅞ x 5⅝	8⅞ x 3¾	7⅛ x 4 7/16	5⅝ x 4 7/16	4 7/16 x 2 1/16
15⅝ x 5	10 x 7⅞	10 x 3 13/16	7⅞ x 5	7⅞ x 3⅜	6⅝ x 3 13/16	5 x 3 13/16	3 13/16 x 2⅛
15½ x 5 1/16	10⅛ x 7⅝	10⅛ x 3⅞	7⅝ x 5 1/16	7⅝ x 3⅜	6⅝ x 3⅞	5 1/16 x 3⅞	3⅞ x 2 7/32
17 x 6⅝	13⅛ x 8½	13⅛ x 4½	8½ x 6⅝	8½ x 4½	9 x 4½	6⅝ x 4½	4½ x 3⅜
13½ x 4½	8½ x 6⅝	8½ x 4⅝	6⅝ x 4½	6⅝ x 2⅝	5⅝ x 3⅜	4½ x 3⅜	3⅜ x 2⅛
13½ x 4⅜	8½ x 6⅜	8½ x 3 15/16	6⅜ x 4⅛	6⅜ x 2½	5⅛ x 3 15/16	4⅛ x 3 15/16	3 15/16 x 2 1/16

The various photographically prepared papers will be found under their respective headings.

PAPER, ALBUMENIZED.—See Albumenized Paper.

PAPER, BARYTA.—Paper coated with Baryta chalk and gelatine with a little tinting matter added. It is used for coating with gelatino-chloride emulsion, as the chalk substratum keeps the gelatine film on the surface of the paper. It is chiefly used, however, for making high-class prints by the Collotype process.

PAPER, BLOTTING,—A thick, bibulous, unsized paper, much used in photography for absorbing superfluous moisture from prints, plates, etc. It is essential that for many purposes a chemically pure kind be used. This is best obtained from a good dealer in photographic materials. Ordinary blotting paper usually contains a large quantity of hypo used as an antichlor.

After silver prints are washed they are usually placed between sheets or boards of blotting paper to dry. The paper should not be used too often, as it eventually becomes impregnated with fixing salt, which is likely to be very detrimental to the subsequent permanency of the pictures.

PAPER CLIP.—A clasp for holding and hanging up paper. They are made of metal, wood and glass.

* These tables were drawn up under the direction of Colonel H. R. Thuellier, R.E., by Colonel J. Waterhouse, assisted by others, for the Survey of India Department.

PAPER, FILTERING.—See **Filtering Paper.**

PAPER, MATT.—A paper having a matt or dead surface. When salted and sensitized it gives very artistic prints. See **Matt-surface Paper.**

PAPER NEGATIVE —A negative made upon a paper support in the place of the glass-plate usually used. The advantages of paper over glass are at once apparent. For tourists the reduction in the weight is naturally a great advantage; and further, it is more easily stowed away—a hundred negatives can be placed away in a single book. It is usually used in a roll-holder or roller slide (*q.v.*), the various exposures being made on a long band of the sensitized paper. The emulsion used for preparing the paper is similar to that employed in the manufacture of dry-plates. The drawbacks to the use of paper instead of glass as a support are, first, its opacity in requiring longer time to print the positives*; secondly, the reproduction of the grain of the paper in the positive.

PAPER, NON-ACTINIC.—See **Non-actinic Medium.**

PAPER, OILED.—Prepared by brushing sheets of paper over with boiled oil, and suspending them till dry.

PAPER, SENSITIZED.—See **Sensitized Paper.**

PAPER SIZE.—Writing papers are usually sized with gelatine prepared from tanners' and parchment makers' clippings. Plate paper that is intended to receive impressions in colors is sized with a clear solution of isinglass. For printing papers a compound of alum and resin dissolved in a solution of soda, and combined with potato starch, is usually used. This is mixed with the paper pulp. Starch is also used either as a paste or as a clear solution.

PAPIER MACHE.—A material composed chiefly of paper. The common varieties are prepared by pulping any kind of mixture of different kinds of paper into a homogeneous mass of a doughy consistence. The pulp is rolled into thick sheets, and afterwards pressed in a mould to the shape required. The surface then can be painted with oil or size colors, or varnished. It is used in photography for making dishes or baths. For this purpose it is very useful, owing to its lightness and toughness.

PAPYROTINT PROCESS.—A photo-lithographic process invented by Husband. It is a modification of Captain Abney's improved method of papyrotype. It is specially suitable for the reproduction of subjects in half-tone. The advantage it possesses over other methods are that a transfer can be taken in greasy ink, for transfer to stone or zinc, direct from the negative, the requisite grain being simply obtained by a chemical change. The method is as follows:—Any good surface paper is first floated on a bath of

Gelatine (Nelson's Flake)	8 ounces
Glycerine	1½ ounces
Sodium chloride	2 ounces
Water	50 ounces

The solution must not be over-heated, and must be free from bubbles. The paper after floating is dried at a temperature of 60 deg. F., and will keep for years. It is sensitized on

Potassium bichromate	1 ounce.
Sodium chloride	½ ounce.
Ferricyanide of potassium	100 grains.
Water	30 ounces.

The paper is dried in the dark room, temperature about 70 deg. F. When dry it is exposed under the negative in an ordinary printing frame. Sunlight is preferable. The image will appear on the transfer paper, and when of a dark fawn color on a yellow ground it is sufficiently printed. It is then laid in a bath of cold water for about ten minutes until the soluble gelatine has absorbed its full quantity of water. It is then removed, placed on a flat plate, and all superfluous moisture removed with a piece of blotting paper.

The action of the light has been to render the parts to which it has penetrated through the negative partly insoluble, and at the same time granulated. A hard transfer ink is now composed of

White virgin wax	½ ounce.
Stearine	½ ounce.
Common resin	½ ounce.

These are melted together in a crucible over a small gas jet, and to them are added four ounces of chalk printing ink, and the mixture reduced to the consistency of cream with spirits of turpentine. A soft sponge is saturated with this mixture and rubbed gently over the exposed paper (in this stage the nature os the grain can be best seen). An ordinary letterpress roller charged

* Various methods are employed to render the paper translucent. See under Translucent.

with a little ink from the inking slab is then passed over the transfer, causing the ink to adhere firmly to the parts affected by the light, and removing it from the parts unacted upon. The transfer is next put into a weak bath of tannin and bichromate of potash for a few minutes, and when taken out the surplus solution should be carefully dried between clean sheets of blotting paper. The transfer is hung up to dry, and when thoroughly dry the whole of the still sensitive surface should be exposed to light for about two minutes. A weak solution of oxalic acid (about 1 in 100) should be used for dampening the transfer, and this applied to the back with a soft sponge. After it has been damped three or four times it is carefully removed and placed between clean sheets of blotting paper. A cold polished stone is then set in the press, and after everything is ready the transfer is placed on the stone and pulled through twice. The stone or scraper is reversed, and the transfer is again twice pulled through. A moderate pressure and a hard backing sheet should be used, care being taken not to increase the pressure after the first pull through. The transfer is taken from the stone without damping, when it will be found that the ink has left the paper clean. Gum up the stone in the usual way, but if possible let the transfer remain a few hours before rolling up. Do not wash it out with turpentine, and use middle varnish to thin down the ink.

PAPYROTYPE or **PAPYROGRAPHY.**—A method of printing from paper or pasteboard covered over with a calcareous substance. A modification of photo-lithography, paper being used as a support in place of a stone.

PAPYROXYLINE.—A kind of pyroxylin made from paper. See **Pyroxylin.**

PARA-AMIDO-PHENOL (Formula C_6, H_7 NO, molecular weight 109).—A derivative of phenol or carbolic acid, a product of the distillation of coal tar and is prepared by the reduction of para-nitro-phenol or the nitro-phenol with tin and hydrochloric acid, crystallizes in fine needles, melts at 140 degrees C, is soluble in 90 parts of water and in 22 parts of absolute alcohol. It is used as a developing agent. A formula for its use will be found under **Developer.**

PARABOLA.—In conic sections, a plane curved of such a form that if from any point in the curve one straight line be drawn to a given fixed point, the other perpendicular to a straight line given in position, these two lines will always be equal to one another.

PARABOLIC LENS.—A lens ground to a parabolic surface would be entirely free from spherical aberration. It could only be ground, however, with very great difficulty, so that these lenses are no longer made, spherical aberration being nearly wholly overcome by other means.

PARABOLIC REFLECTOR.—See **Optics.**

PARAFFIN.—A solid, fatty substance occurring along with liquid oils in petroleum, and in the native state in coal and bituminous strata. It is a white, solid, translucent substance, without taste or smell. It takes its name from the fact that it is acted on with great difficulty by other substances.

PARAFFIN OIL.—See **Petroleum.**

PARCEL CAMERA.—An instantaneous camera made in the form of an ordinary brown paper parcel to avoid detection.

PARCHMENT PAPER can be made by immersing ordinary unsized paper in sulphuric acid, diluted with about half its volume of water. After a few moments it is withdrawn, and will be found to have assumed a new appearance, resembling animal parchment, and its strength is quite doubled. After immersion in the acid, it is washed in water, and in diluted ammonia, and again in water.

PARTITION.—Partitions in cameras are usually constructed of thin wood, or tin blackened over with a dull black varnish. They require to be fitted in stereoscopic cameras to prevent the two views from overlapping. They are also used—but rarely—when a subject is required to be taken upon which it is hardly worth while expending a large plate, to protect the remaining half from the light during the exposure.

PASTE.—A good flour paste may be made by working a little flour with cold water, and then pouring boiling water on it. An arrowroot paste may be made as follows: Thoroughly mix 600 grains of the best Bermuda arrowroot with 375 grains of cold water in a capsule. Next add 10½ ounces of water and 60 grains of gelatine in fine shreds. Boil for about five minutes, constantly stirring until the liquid becomes clear. Allow it to get cold, and then stir in two ounces of alcohol and about five to six drops of pure carbolic acid. This paste should be kept in well-corked bottles. See also **Mountant.**

PASTE, ENCAUSTIC.—See **Encaustic Paste.**

PASTE-DOWN MOUNT.—See **Mount.**

PASTEL PORTRAIT.—A photograph, usually an enlargement, worked over with chalk colors prepared by mixing fine pipeclay, gum, water, and the required pigment.

PATENT.—The following is the law relating to U. S. Patents:*

Suits for redress on account of infringement of patents are brought in the United States Circuit Court for the District where the defendent resides. Redress may be had through an injunction preventing further infringement and an accounting of the damages caused the patentee, or the profits, gains or advantages made by the infringer.

Until recently appeals from decisions rendered by the United States Circuit Court were necessarily taken to the Supreme Court of the United States, and, owing to the great amount of business done by the latter, a delay of at least four years was suffered by an appellee.

Very recently a new Court, designated the Circuit Court of Appeals has been provided. Appeals may hereafter be taken to this Court, and are likely to be reached and disposed of quite expeditiously. This is of particular advantage to patentees, in view of the fact that their monopolies run but a limited time.

Patents are issued in the name of the United States and under the seal of the Patent Office to any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof, not known or used by others in this country, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, and not in public use or on sale for more than two years prior to his application, unless the same is proved to have been abandoned; and by any person who, by his own industry, genius, efforts, and expense, has invented and produced any new and original design for a manufacture, bust, statue, alto-relievo or bas-relief; any new and original design for the printing of woolen, silk, cotton, or other fabrics, any new and original impression, ornament, pattern, print, or picture to be printed, painted, cast, or otherwise placed on or worked into any article of manufacture; or any new, useful, and original shape or configuration of any article of manufacture, the same not having been known or used by others before his invention or production thereof, nor patented or described in any printed publication, upon payment of the fees required by law and other due proceedings had.

Joint inventors are entitled to a joint patent; neither can claim one separately. Independent inventors of distinct and independent improvements in the same machine can not obtain a joint patent for their separate inventions; nor does the fact that one furnishes the capital and another makes the invention entitle them to make application as joint inventors; but in such case they may become joint patentees.

Every patent contains a grant to the patentee, his heirs or assigns, for the term of seventeen years, of the exclusive right to make, use, and vend the invention or discovery throughout the United States and the Territories, referring to the specification for the particulars thereof.

If it appear that the inventor, at the time of making his application, believed himself to be the first inventor or discoverer, a patent will not be refused on account of the invention or discovery, or any part thereof, having been known or used in any foreign country before his invention or discovery thereof, if it had not been before patented or described in any printed publication.

Letters Patent granted a foreign government will not, while in force, prevent the inventor from obtaining a patent in the United States, unless the invention shall have been introduced into public use into the United States more than two years prior to the application. But every patent granted for an invention which is the subject of Letters Patent still in force and previously granted to the same inventor in a foreign country will be so limited as to expire at the same time with such foreign patent, or, if there be more than one, at the same time with the one having the shortest unexpired term, but in no case will it be in force for more than seventeen years.

Applications.—Application for a patent must be made in writing to the Commissioner of Patents. The applicant must also file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he must explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions, and particularly point out and distinctly claim the part, or improvement, or combination which he claims as his invention or discovery. The specification and claim must be signed by the inventor and attested by two witnesses.

The applicant shall make oath that he verily believes himself to be the original and first inventor or discoverer of the art, machine, manufacture, composition, or improvement for which he solicits a patent; that he does not know and does not believe the same was ever before known

* From "American Annual of Photography."

or used, and shall state of what country he is a citizen. Such oath may be made before any person within the United States authorized by law to administer oaths, or, when the applicant resides in a foreign country, before any minister, charge d'affairs, consul, or commercial agent holding commission under the Government of the United States, or before any notary public of the foreign country in which the applicant may be.

When the nature of the case admits of drawings, the applicant must furnish one copy signed by the inventor or his attorney in fact, and attested by two witnesses, to be filed in the Patent Office. In all cases which admit of representation by model, the applicant, if required by the Commissioner, shall furnish a model of convenient size to exhibit advantageously the several parts of his invention or discovery.

On the filing of such application and the payment of the fee required by law, if on such examination, it appears that the claimant is justly entitled to a patent under the law, and that the same is sufficiently useful and important, the Commissioner will issue a patent therefor.

Assignments.—Every patent or any interest therein shall be assignable in law by an instrument in writing; and the patenteee, or his assigns or legal representatives may, in like manner, grant and convey an exclusive right under his patent to the whole or any specified part of the United States.

Reissues.—A reissue is granted to the original patentee, his legal representatives, or the assignees of the entire interest when, by reason of a defective or insufficient specification, or by reason of the patentee claiming as his invention or discovery more than he had a right to claim as new, the original patent is inoperative or invalid, provided the error has arisen from inadvertence, accident, or mistake, and without any fraudulent or deceptive intention. The applications must be made and the specifications sworn to by the inventors, if they be living.

Caveats.—A caveat under the patent law is a notice given to the office of the caveator's claim as inventor, in order to prevent the grant of a patent to another for the same alleged invention upon an application filed during the life of the caveat without notice to the caveator.

Any citizen of the United States who has made a new invention or discovery, and desires further time to mature the same, may, on payment of a fee of $10, file in the Patent Office a caveat setting forth the object and the distinguishing characteristics of the invention, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office and preserved in secrecy, and shall be operative for the term of one year from the filing thereof.

An alien has the same privilege, if he has resided in the United States one year next preceding the filing of his caveat, and has made oath of his intention to become a citizen.

The caveat must comprise a specification, oath, and, when the nature of the case admits of it, a drawing, and, like the application, must be limited to a single invention or improvement.

Fees.—Fees must be paid in advance, and are as follows: On filing each original application for a patent, $15. On issuing each original patent, $20. In design cases: For three years and six months, $10; for seven years, $15; for fourteen years, $30. On filing each caveat, $10. On every application for the reissue of a patent, $30. On filing each disclaimer, $10. For certified copies of patents and other papers, including certified printed copies, ten cents per hundred words. For recording every assignment, agreement, power of attorney, or other paper, of three hundred words or under, $1; of over three hundred and under one thousand words, $2; of over one thousand words, $3. For copies of drawings, the reasonable cost of making them.

PATENT PLATE.—See **Glass.**

PEARLASH.—A crude potassium carbonate obtained from the ashes of plants by dissolving the calcined mass in water, decanting the clear solution, and evaporating it to dryness in flat iron pans. By constant stirring towards the end of the process the pearlash is obtained in a semi-granular state. It is very impure, containing variable quantities of potassic silicate, sulphate, chloride, etc.

PELLET'S PROCESS.—A process of printing with salts of iron, giving blue lines, on a white ground. The most recently given formula is the following:

Gum arabic	385 grains
Sodium chloride	46 grains
Tartaric acid	62 grains
Perchloride of iron	123 grains
Water	3½ ounces

Well-sized smooth paper is evenly coated with the mixture, dried in the dark, and exposed beneath the negative The image is developed in a saturated solution of ferrocyanide of potassium, and fixed in a 1 in 20 solution of hydrochloric acid. See also **Cyanotype.**

PELLICLE.—A thin skin or film. Photographically it is applied to a coating of an emulsion when the solvents have evaporated. Many attempts have been made to use gelatine or collodion pellicles without the necessity of the glass support. See **Film.**

PENCIL OF LIGHT.—A term applied to rays of light diverging from or converging to a point. If the point is taken at an infinite distance the rays are then usually regarded as parallel, the amount of divergence or convergence being so small, and the pencil then becomes a beam of rays.

PENCILS.—Pencils are used in photography chiefly in retouching negatives; for this purpose H to H H H H H H pencils are the most suitable. See **Retouching.**

The following recipes* for preparing pencils for writing on glass, porcelain, metal, etc., may be found useful:

BLACK.

Finest lampblack	10 parts
White wax	40 parts
Tallow	10 parts

WHITE.

Kremser white	40 parts
White wax	20 parts
Tallow	10 parts

LIGHT BLUE.

Prussian blue	10 parts
White wax	20 parts
Tallow	10 parts

DARK BLUE.

Prusian blue	15 parts
White wax	5 parts
Tallow	10 parts

YELLOW.

Chrome yellow	10 parts
White wax	20 parts
Tallow	10 parts

The color is mixed with the body of wax and tallow while warm, triturated, exposed to air for drying, so that the mass can be pressed by means of a hydraulic press into round pencils in the same way as lead pencils are formed. The pencils are dried after pressing by exposing them to the air until they have the proper consistence, and are then glued into wood.

PENDULUM.—A simple pendulum is a heavy particle suspended by a fine thread from a fixed point about which it oscillates without friction. No simple pendulum can of course exist. All made by man are compound, in which there gravitates, not a particle, but a heavy body called a bob, and the laws of friction must also be considered.

The time of vibration of a pendulum is directly as the square root of its length, and inversely as the square root of the accelerating force of gravity. The length of the arc through which it vibrates does not affect the result.

The knowledge of the construction of a seconds pendulum, will sometimes be useful in timing exposures when a chronometer is not handy. All that is required is to get the exact length. This differs in direct proportion to the force of gravity at the place. In London (lat. of Greenwich Observatory, 51 deg. 28 min. N.) at the sea level the exact measure required is 39·13983 inches.

PENNY PHOTOGRAPH.—A photograph obtained for one penny. Machines have recently been constructed with which, if a coin of the value of one penny is placed in a slot, the machinery is set in motion, and a ferrotype plate exposed, developed, fixed and dried. The construction of these machines is given under **Automatic Machines.**

PERCHLORIDE OF GOLD.—See **Gold Trichloride.**

PERCHLORIDE OF MERCURY.—See **Mercuric Chloride.**

PERFORATED BASE-BOARD.—In many makes of cameras the base-board, instead of being solid, has a large round hole cut in the center, or is constructed as a framework only. These are termed perforated base-boards, and by their use the lens need not be removed from the camera when folding it up, as it falls through the hole in the base-board, and is always in a position ready for use. Much time is, of course, saved by this arrangement; it is only necessary to see that the base-board still remains firm and rigid.

PERFORATING GLASS.—To make a hole in glass, an ordinary well-tempered steel drill is the best tool. The drill must be kept moistened with turpentine in which some camphor has been dissolved, or with diluted sulphuric acid, or with ordinary kerosene oil.

* "British Journal Almanac," 1891.

PERISCOPIC LENS.—See **Lens.**

PERMANENCY.—The question of the permanency of photographic images is one that has been much discussed. It is a well-known fact that silver prints made thirty or forty years ago have almost entirely faded away. Here and there prints will be found of that age in quite good condition, the reason lying, in all probability, in the method of manufacture adopted. It is pretty generally known that hypo remaining in the picture will soon cause it to fade. To thoroughly eliminate this, several so-called hypo eliminators have been recommended. These should never be used, for while removing the hypo from the film they leave another composition which is more likely to cause the print to fade than the hypo salt itself. Good washing is the only true eliminator. This must be thorough and not too long. Too prolonged washing tends to decompose the prints, and will cause them to fade more rapidly. The larger the quantity of gold used in the toning process, the longer will be the lasting qualities of the prints. This should be borne in mind by those economical workers who endeavor to make a tube of gold tone a large number of sheets. Another cause of fading is due to impurities in the mount and the mountant. Unmounted prints placed between sheets of chemically pure paper will last considerably longer than mounted ones. Good quality mounts and a pure, simple paste should be used.

Silver prints are probably the least permanent of any photographic pictures. Gelatino-chloride of silver papers (Celerotype, Aristotype, etc.), are much more permanent than albuminized paper.

Bromide and platinotype prints are also considered as permanent.

The most permanent are undoubtedly the pictures produced by the carbon or Woodbury process. In these the images are composed simply of gelatine and lampblack, two permanent substances.

PERMANENT SUPPORT.—See **Carbon Process.**

PERMANGANATE OF POTASH.—See **Potassium Permanganate.**

PERNITRATE OF IRON.—See **Ferric Nitrate.**

PEROXIDE OF HYDROGEN.—See **Hydrogen Peroxide.**

PERSPECTIVE.—See **Plane Perspective.**

PERSULPHATE OF IRON.—See **Ferric Sulphate.**

PETROLEUM.—Synonyms, *earth oil, mineral oil, paraffin oil,* etc.)—A term applied to a variety of inflammable liquids found in different parts of the earth. A light petroleum oil is much used for illuminating purposes. Many optical lanterns are constructed for burning petroleum. The whiteness of the light obtained may be increased considerably by dissolving a little camphor in the oil (about one ounce to the pint) before lighting.

PHANTASMOGRAPH.—A name given to an apparatus for printing lantern slides. It consists of a long box, at one end of which the quarter-plate negative and the lantern plate in contact with it are placed. The hinged door at the other end of the box admits the light for exposure. By this means all side or extraneous light is excluded.

PHENIC ACID.—See **Carbolic Acid.**

PHENOL.—See **Carbolic Acid.**

PHENOL PHTHALEIN (Formula, $C_{20}H_{14}O_4$; synonym, *dihydroxy-diphenylphthalide*).—A substance employed in an alcoholic solution as a test for organic acids. No alteration takes place with these, but if alkali be present its color is changed to a reddish purple. This test, however, cannot be relied on in the presence of ether, ammonia, or carbon dioxide. It is insoluble in water.

PHENYL HYDRATE.—See **Carbolic Acid.**

PHOSPHATE.—A salt of phosphoric acid. The principal are phosphate of ammonia, copper, iron, lead, calcium and soda. Soluble phosphates give with barium nitrate a white precipitate soluble in hydrochloric acid, and with silver nitrate a yellow precipitate soluble in nitric acid.

PHOSPHORESENCE.—The property possessed by many substances of emitting light under certain conditions.

PHOSPHORESCENT PHOTOGRAPHS.—See **Luminous Photographs.**

PHOTO CERAMICS.—A process of producing burnt-in photographic images on porcelain, pottery, glass and other similar materials. There are two principal methods—the substitution process invented by Du Motay and Maréchal, and the dusting-on process of Poitevin.

The best description of the substitution process is that of Mr. N. K. Cherrill, and from which the following information is mostly taken :*

A piece of glass is first cleaned with nitric acid, well washed, dried, polished, and coated three times with the collodion.

This done, the plate is plunged into the nitrate bath before the collodion has been allowed to become too much set. The nitrate bath is a solution of thirty grains of pure silver nitrate dissolved in an ounce of pure water, and sunned all the while it is not in use, and when used rendered acid in the proportion of two drops of pure nitric acid to a half-gallon of solution. The plate is left in this solution until all the greasy marks have disappeared ; it is then taken out at once and placed in a funnel to drain for about five minutes, and is then inserted in the dark slide of the copying camera. The camera is so arranged that the light which passes through the negative to be copied comes only through one of the side lights of the studio. The exposure varies from five to twenty seconds. If the enamel to be taken is of small size it is preferable to put a mask on the negative and to block out all the light except that actually needed, as this enables one to take four or five images side by side by simply pushing the camera dark slide a little way each time. The exposure and development of the image is a matter requiring great care and attention, as on the complete success of the transparency the whole process lies. The developing solution is made up with—

Pyrogallic acid	12 grains
Glacial acetic acid	4 drachms
Alcohol	4 "

Water to fill a 12 oz. bottle.

In warm weather this may be more dilute—say as far as giving 20 ounces of water to the same quantity of pyro. Then, of course, more alcohol will be needed. The developer should be made three days before required for use, as at first it is too vigorous, although it must not be kept too long, as it then deteriorates in the other direction.

The image of the positive is developed slowly and until it obtains the exact density required, and at the same time gives the right amount of detail in the high lights. The image, when examined by reflected light, should show nearly all the drawing and shading of the subject, while, when viewed by transmitted light, it would show up with great perfection.

The plate is then well washed and fixed with a weak solution of cyanide of potassium, after the application of which it is again thoroughly well washed.

After washing, a small portion of the film at one corner of the plate is broken away, and a direct stream of water is made to run on this corner, striking the bare glass. This will gradually detach the film from the glass. The detached film is then floated on to a clean piece of glass and all unnecessary parts removed. The film is again washed while on the glass, and then lowered gently into a dish of water.

The next operation is the toning. A 16-ounce bottle, half-filled with water, is placed in a saucepan containing water. This arrangement is set on the fire or on a gas stove until the water in the pan begins to boil. Next is placed in the bottle an ounce of potassium-chloride of iridium, and it is filled up with cold water and returned to the saucepan. The water is then kept hot and the bottle shaken occasionally. After half-an-hour remove the bottle and place it where the contents will become quite cold. To make up the toning bath place twelve ounces of pure water in a bottle ; add to it 14 drachms of the iridium solution, and shake up well. Now add drop by drop, and shaking well between each addition, seven drachms of a solution of gold chloride (1 grain to 1 drachm). The bath is then ready for use, but improves by keeping, which it will do indefinitely. It is particular to note that the solution in the iridium bottle will have a nearly black sediment, which is undissolved chloride. When all the clear solution has been used up, more water is added, and this remainder used in the same manner as the first, but care being taken, however, that too much water is not added, as a quarter of an ounce of the chloride will not make two sixteen ounce bottles full of the saturated solution, but only about one and a half.

To use the bath, pour it into a dish to the depth of about half-an-inch, and have ready at hand another dish containing clean water, and a small dish containing some pieces of glass somewhat smaller than the films to be toned. Now take one of these pieces of glass, and slip it under the film containing a transparency to be toned, and gently raise the glass to the surface (at the same time manipulating the film with a camel-hair brush, held in the right hand) in such a manner that when the glass and film on it are lifted out of the water there will be an edge of film about a quarter of an inch wide lapping over one edge of the glass. The action of the water as the plate is taken out will wash this piece or edge of film round to the back of the plate, and by so doing will fix the transparency on the glass in a very satisfactory manner. If care be taken that the edge where the film laps over is kept uppermost or highest, a very considerable stream of water may be poured on the film without any danger of it slipping. Having got the film on the glass it should be rinsed under the tap, and can then be transferred to the toning bath. To do this, turn the glass over so that the body of the film is underneath, lower it gently

* Photographic Year Book, 1886.

under the surface of the solution, and with a brush disengage the lap of the film where it had turned over the edge of the plate, now, of course, uppermost. As soon as this is done the film will move off into the solution free of the glass, which can then be removed. When the film has floated free for about a minute turn it over with a brush and note carefully if the deeper shadows are toned through, so as to give one uniform tint to the whole film. When this is effected it is removed with the piece of glass used in the same manner as before described and transferred to a dish of cold, clean water. Free it from the glass and gently agitate the water to remove the toning solution adhering to it As each film is toned it is placed in this dish of water, and when all are finished they are changed to another dish of cold water, taking each film up with the glass as before described.

The films are then ready for mounting on to the tablets. Have two dishes, one containing cold water, and another filled about half an inch deep with ammonia solution.

Ammonia .880	6 drachms
Water	12 ounces

(Keep well corked.)

Half an ounce of this mixture diluted with one pint of water makes the bath into which the films are to be plunged.

Place in the dish of clean water a clean glass, and on that an enamel tablet carefully washed. Take another glass, and with it remove one of the toned films from the dish in which it was washed, and plunge the same into the ammonia bath. As the film enters the solution the time is noted by the second hand of a watch, and after it has been in twenty seconds it is removed and plunged quickly into the water where the tablet is. Disengage the glass and slightly agitate the water in the dish to give the film a wash. Then take up with the left hand the piece of glass on which the tablet rests, and raise it about half way to the surface, then, manipulating with the brush, bring it into its proper position on the tablet. It is then removed and placed slightly on edge to drain.

The tablets being curved, it is necessary to remark that a little care must be taken in the manipulation in order to make the films lie flat.

When almost dry the tablets are to be removed from the glass plates upon which they were lifted from the water. To do this, place the plate in a level position, and with a sharp-pointed stick tear away the useless film around the edges of the tablet, slip a thin knife under the latter, and lift it off the glass on to a sheet of blotting paper, and cover over with a bell jar or similar contrivance to protect from dust.

The next process is the burning-in; this may be done at once, or it may be left for weeks without any change.

A gas muffle furnace should be used in preference to one heated by coke. Whichever is used, however, it should be ready and at the full heat, a clear cherry red inclining to white, but by no means a full white heat. Too much heat is a mistake, as it renders the process quite unmanageable, and produces no better results for the extra difficulty in working.

Figures 329–330 illustrate the furnace used.*

When enamels of small size only are attempted, the form here illustrated and described will do good work. Its construction is so simple that any good metal worker can construct it.

Fig. 529 is the front elevation, and Fig. 330 the side elevation. The muffle, M, is made of moderately thick sheet brass, permanently closed at one end, with a hinged or sliding door, provided with a peep-hole in front. The muffle slides into the furnace on two iron bars let into the walls. One of these bars is seen in Fig. 330.

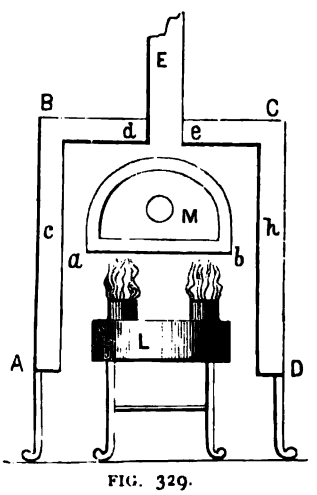

FIG. 329.

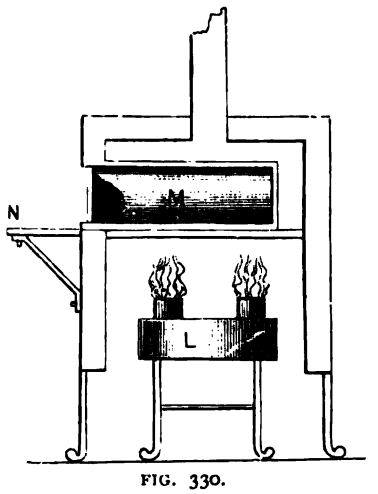

FIG. 330.

The furnace walls, A, B, C, D, Fig. 329, are of thick iron plate and doubled, the space between being filled with ashes or some other non-conductor of heat. The furnace is supported by four iron legs attached to the outer wall by screws, in order to be easily removed for convenience of transportation. A chimney, E, also detachable, fits into a hole in the middle of the furnace top. Heat is generated by a Berzelius or Liebig spirit lamp, having two or more wicks, which stands on an iron tripod.

The opening in the walls by which the muffle is introduced into the furnace must be of

* Burbank's Photographic Printing Methods.

such a size and shape as to be completely closed when the muffle is in place. A shelf, N, of thick iron plate, is fastened by brackets just underneath this opening.

It is impossible to give any specific dimensions, as they are determined by the size of the muffle, which must be large enough to hold the largest piece of enamel likely to be fired.

The height of the muffle need not be more than three inches, nor its other dimensions more than seven by nine inches. A muffle four by five, by two-and-one-half inches, is, perhaps, as large as can be advantageously used in this simple form of furnace. The furnace proper should be about seven inches high, and the legs about the same. The chimney is a piece of iron pipe two inches in diameter, and about fifteen inches in height. The hot-air space surrounding the muffle may be one or two inches larger each way. The lamp must not be brought too near the bottom of the muffle, or it will not burn well.

The burning is the most delicate operation, and every care is necessary to secure the result at the very best point.

Take one of the tablets and place it upon a piece of fireclay in front of the muffle at a distance of about six or eight inches. The fireclay should be supported in such a way as to tip the enamel towards the heat, so that the rays may fall upon it as near as possible equally all over. When it is roasted in this manner it is moved a little nearer, and then a little nearer, examining it each time. As soon as the heat has turned the color of the film brown in the least degree it may be dealt with fearlessly. The fireclay with the enamel on it may be placed level, just in the mouth of the muffle, where, in a few moments, the film will take all the shades of brown until it gets quite dark, when it is pushed into the heat. As soon as it is pushed in the heat it must be watched carefully. It will appear to get perfectly black all over, and then, all of a sudden, the whites of the picture will be seen coming out quite clear. Directly this takes place draw the tablet to the mouth of the muffle and remove it to the outside to cool a little gradually, and then take the tablet and place on a piece of wood to get cold. All the beauty of the enamel will by this time have disappeared, the whites will stand out, and the few tones near them will have some clearness, but all the other tones will be a dark and confused mass, hardly distinguishable one from the other. This is the true characteristic of a good enamel at this stage. It is now ready to glaze.

The enamel glaze is made in large quantities at Worcester, and can be bought in the form of a fine powder resembling flour. Place about a thimbleful of this in a bottle, and add an ounce of alcohol. To make the glazing solution, take a two-ounce bottle, and put into it half-an-ounce of plain collodion, and add to it a quarter of an ounce of methylated ether and half an ounce of alcohol. Next add as much water as possible without precipitating the pyroxyline. About six or eight drops will suffice. Shake up the bottle containing the glaze in alcohol, and let it remain for a few minutes, and then carefully add some of the upper part of the mixture to the diluted collodion—sufficient to make it slightly opaque.

When the enamel is quite cold some of this glaze mixture is poured over it, and it is immediately tilted to allow the superfluous glaze to run off. When the collodion is set, place the tablet in a muffle on a piece of fireclay, and gradually introduce it to the full heat, keeping careful watch that the burning does not proceed too far. The glaze should only just melt, when the enamel should be pulled out again, and placed on the wood block to get cold once more. The image is now fixed indelibly, but the picture is not, however, at its full beauty, as one glazing will not be sufficient; thedark portions would still retain a matt appearance. This is overcome by repeated glazing, no enamel being perfect until it has been glazed five or six times. A little trouble might be saved by lessening the number of burnings and making the glaze thicker, but the best results are not obtained in this manner.

By this process we obtained an image consisting of pure metallic silver, gold, and iridium in an extremely fine state of division fixed to the surface of an imperishable tablet, and protected by an equally hard, permanent and impermeable glaze.

Ceramic colors may be applied to enamels, and burnt in in the same manner.

Enamel may be retouched with a medium prepared by burning waste films and trimmings in the muffle, collecting the ash, and adding to it a small quantity of the glaze powder and a drop of an essential oil. The work being burnt into the enamel takes the same color and surface as the rest of the picture. With enamels that have been spoiled, the image can be removed with a little fluoric acid, and the tablet used again.

PHOSPHORETTED HYDROGEN. (Synonym, hydrogen phosphide).—Obtained in three forms—gaseous, liquid and solid. The gaseous phosphide (H_3P) is prepared by heating hydrated phosphorus acid in a small retort. It has a disagreeable odor, is slightly soluble in water, and burns with a brilliant flame.

Liquid phosphide (H_2P) is obtained in small quantities when calcium phosphide is treated with water. The gas evolved is passed through a tube surrounded by a freezing mixture, which condenses this compound as a colorless and highly refractive liquid. In contact with air it inflames instantly. Solid phosphide is HP_2 formed by the action of light on liquid phosphide.

PHOSPHORUS, (Symbol P; atomic weight, 31).—A non-metallic element found in the unstratified rocks, the soil, the organism of plants, and the bodies of animals. It is insoluble. in water, but soluble in ether, chloroform, benzine, turpentine, and other oils and carbon bisulphidle It can be prepared artificially from bone ash or other phosphates by treatment with two-thirds of their weight of sulphuric acid and water and sublimation with charcoal and sand. It has but little interest photographically. It is sold in sticks, which must be kept in bottles filled with water.

PHOTO.—Pertaining to or relating to light. Also used as an abbreviated term for photograph.

PHOTO AQUATINTS.—A process for printing pictures from intaglio copperplates. The process is said to be much simpler than photogravure, which it resembles.

PHOTO CARICATURES. (See **Caricature photos.**)—Humorous portrait photographs can be made by several different methods. The simplest is perhaps by holding under the head of the sitter a white card having a small body. A white back ground is used, so that in the photograph a large head and a little body is all that appears. See fig. 331.

PHOTO CARICATURE. FIG. 331.

PHOTO CAUSTICS.—A name given to photo-lithographs produced in half tone by means of a Meisenbach ruled negative.

PHOTO-CHROMOSCOPE.—An arrangement for showing photographs tinted with different colors. It consist of a frame opening not unlike a retouching desk, this frame being arranged to support the picture in a suitable position in front of reflectors. To use it unmounted photographs are taken and the skies cut away, the photograph then being rendered transparent by a suitable medium. The transparent photograph is then placed upon the glass front of the instrument whilst behind it, in a suitable position is a sheet of artificial clouds which are tinted blue, and by the use of a series of colored pieces of cardboard of various tints the light from which is reflected through the picture, a variety of pleasing effects such as night, sunset, sunrise and so on may be obtained.

PHOTOCHROMY.—Photography in colors. See **Heliochromy.**

PHOTO-CHRONOGRAPHY.—(See **Chrono-photography.**)

PHOTO-CHEMICAL ACTION.—See **Photographic chemistry.**

PHOTO-COLLOGRAPHIC PROCESS.—A simplified process. See **Warneke's process.**

PHOTO COLLOTYPE.—See **Collotype.**

PHOTO CRAYON PROCESS.—A process introduced by Sarony about the year 1870. It contained in making a photographic transparency on glass, which was afterwards backed up with paper, on which a number of lines, hatchings, or stippling were lithographed, giving the portrait the appearance of a crayon work.

A similar process adopted by Henderson is the following :—A piece of course ground glass is laid over a portrait, and the glass worked on with a lead pencil or crayon all round, and, if necessary, over the lower part of the figure. The ground glass when viewed by transmitted light will then represent beautiful broken up granular markings. A thin negative is then made from this ground glass from transmitted light, reduced or enlarged as required. This negative to be superimposed with the negative to be enlarged or reproduced, which when developed, will contain all the worked up effects on the ground glass.

PHOTO ELECTRICITY.—The generation of electromotive forces and currents by the action of light on various metallic plates having their surfaces prepared by special processes. The most recent experiments in this direction have been made by Professor G. M. Minchin.* He uses two kinds of cells. One of them consists of a glass tube three or four inches long, in which is some pure methyl alcohol from oil of wintergreen, covering the two plates; platinum wires, sealed into the tube by heat, pass through the glass to the plates. This smaller plate is of absolutely clean, pure tin, a quarter of an inch long, a sixteenth of an inch broad. The larger and sensitive plate is one inch long and one-eighth of an inch broad. This one also is of perfectly pure tin, for any impurity, especially any trace of copper, promotes failure in the results. The plate is first cleaned with sodic hydrate, and afterwards with dilute hydrochloric or hydrofluoric acid ; then it is laid upon a horizontal arm of porcelain so bent at the other end that, on raising from below a dish containing liquor, the said liquid covers the plate. By this method the

* "Photographic News," January 23rd, 1891.

second plate, or the one which has to be covered with a sensitive film, is immersed in the following solution :—

Distilled water	500 c.c.
Nitric acid	3 "
Nitrate of ammonia	15 grammes.

The plate is left in the liquid about four minutes, and becomes covered uniformly with a whitish deposit. The solution is then removed by lowering the dish, and the under surface of the horizontal porcelain support is dried with blotting paper. This dried under surface is then uniformly heated with a spirit flame moved about underneath until the liquid above has evaporated; the surface of the tin plate will then present a dirty slate color. As the heating is continued, a point is reached at which a dark shadow passes over the whole surface of the plate; if the heating be now stopped, sensitive plate is produced, but not one of the maximum sensitiveness. Upon continuing the heat the surface will change into a perfectly white one, and the heating should be continued until the thin vapor or smoke which is given off ceases to appear, and until the smell of nitrous acid entirely disappears. Care must be taken not to melt the tin in this process, and when the treatment is complete, the plate should be plunged into methyl alcohol from pure oil of wintergreen A fine platinum wire has first to be fixed to the top of the plate, either by means of solder with a low melting point, or by passing a wire through a little hole at the top of the plate and then bending the end of the wire back over the top edge; the latter plan is found to give sufficiently good contact for practical purposes. The clean, plain tin plate is sealed to the bottom of the tube by means of its platinum wire; after the methyl alcohol and the other plate are inserted, the upper part of the tube, with the wire from the second plate passing through it, is sealed by heat. All this may be done in daylight. The complete cell has to be left from two to five hours in the dark before it will exhibit its maximum powers.

The tin plate thus rendered sensitive, and mounted in a cell as described, when exposed to good diffused daylight will exert an electromotive force—E M.F. in electricians' language—of half a volt or more, as exhibited by means of the quadrant electrometer, and it will yield a steady stream of electricity for three or four hours, after which the E.M.F. falls off.

Supposing an exposure not to have been too long, the cell will gradually recover itself in the dark; if it be not exposed for more than ten minutes or so at a time it will recover itself in the dark; one of the cells which has been used only in the latter manner has been so employed by Professor Minchin for four years.

Photo electricity is yet in its infancy, but there are many who believe that it has a great future before it. Among the many possibilities are mentioned * a scientic comparison of the relative values of two different lights, the solution of the problem of telephotography, or seeing at a distance, also the question of utilizing the energy of the solar rays for performing useful work by means of photo-electric batteries.

PHOTO-ELECTROTYPE.—A very large number of processes come under this heading. They all consist substantially in first exposing a sheet of chromatized gelatine under a negative. If half-tone effects are to be produced, grained or lined negatives must be used. The effect of the light shining through the negative is to render some parts insoluble and incapable of absorbing water. After exposure the gelatine is either soaked in water to swell the remaining soluble parts, or it is treated with a warm water or an acetic acid bath to wash them right away, leaving the insoluble parts to form an image in relief. From these, moulds in wax or plaster are made, from which a copper relief block for typographic printing is made by the electrotype process.

PHOTO-ELECTROGRAPH.—An arrangement used at Kew observatory for photographically registering the variations of the electrical conditions of the atmosphere.

PHOTO-ENGRAVING.—The earliest process of engraving with the aid of photography was the bitumen process of Niepce. This was, in fact, the earliest process of obtaining permanent images by the action of light. Niepce discovered that certain varnishes became insoluble by the action of light; he covered metal plates with asphaltum or bitumen of Judea, and exposed them to the image in the camera obscura. After the exposures the plates were treated with a solvent, when the unexposed parts were dissolved away, leaving the insoluble negative image of bitumen on the metal plate. To convert this into a positive one, the plate was treated with iodine vapor, which attacked those parts of the metal unprotected by the bituminous image, which was then cleared away with a powerful solvent. By applying an acid to the bituminous images on metal the bare parts are eaten away, and by this means engraved plates were obtained. See **Niepceotype.**

Bolas, the eminent authority upon photo-mechanical processes, thus described the *modus operandi* for producing photo-engraved plates by the bitumen process :—" Bitumen or asphalt

* Professor Minchin at the Physical Society.

dissolves readily in benzole, and the solution runs freely through a paper filter. The solution should not be quite as thick as collodion. A carefully-cleaned copperplate such as the engravers use, is clamped down on to a turn-table. The next step is to flood the plate with bitumen solution, and then to make the table revolve quickly. When it has revolved a few seconds the film will be dry. No other method gives such a uniform and compact film of bitumen as this. After coating it is well to put the plate aside for twelve hours, in order that the film may become harder. It is then necessary to dust it over with French chalk to remove stickiness, and after this it is placed behind a transparency and exposed to light. The time of the exposure may vary from 20 minutes to two days.

When a plate has had the requisite exposure, the next matter is to dissolve away that portion of the bitumen which has not been made insoluble by the action of light. Now, benzole is generally too energetic a solvent for the purpose, and oil of turpentine is often not sufficiently active; but by mixing these together you can get any degree of solvent power which you may require. The workman commences by flooding the plate with oil of turpentine, and if this has not sufficient action he pours it off and adds a little benzole; this begins to produce an effect, and enables him to judge as to the amount of benzole which he may safely add to the oil of turpentine. When he has added this quantity, and has washed away all the soluble bitumen from the plate, it is next thoroughly rinsed with water to remove the oil of turpentine. The plate is next placed in nitric acid, so as to etch the lines where the metal is bare.

Plates from which much printing is to be done are ordinarily covered with a thin film of iron, by the electrolytic method, and as the film of iron is extremely thin, it does not in any way interfere with the printing qualities of the plates. When the surface of a plate begins to wear a little, and the impressions show signs of deterioration, the film of iron is dissolved off by means of dilute sulphuric acid, leaving the copperplate as good as ever. The film of iron, although so thin as not to injure the printing qualities of the plate, is nevertheless sufficiently thick to protect the copper from injury in printing. The plate having been freed from the first worn-out film of iron, is once more coated with a layer of iron, and is again ready for use. When the second film of iron is nearly worn away, and the printer approaches near to the true surface of the copperplate, the iron is again dissolved away, and a new coating of iron is put on. According to this system, one really prints rather from a cast of the plate than from the original plate, and new casts are made as required.

Another method of producing photo-engraved plates from lined subjects is by means of photo-lithographic transfer, the process being similar to photo-lithography, except that a metal plate is being used instead of the stones.

Major de la Nöe's process of photo-engraving, which he terms typogravure, is really an intaglio process, although the printing is similar to ordinary zincography. A prepared zinc plate is coated with a film of sensitive bitumen as already described, and the exposure made under a tracing or a transparency, and the plate afterwards developed in the usual way. The plate is then etched with dilute nitric acid until the depth of about $\frac{1}{110}$th of an inch is reached. The plate is then dried and again coated over with bitumen. The ground is next polished off with a stick of charcoal, leaving the bitumen on the lines, after which the plate is gummed and printed from as in zincography.

Klie's process is the following: A copperplate is dusted over with powdered asphalt, and the plate heated until the particles of asphalt just adhere to the plate. A negative carbon process is then transferred to the copperplate, and the latter is then etched with a strong solution of perchloride of iron. By diluting the solution its action increases; water is consequently gradually added until the solution etches through the thicker parts, until only the high lights remain unetched.

A simple method of photo-engraving line subjects, much practiced on the Continent, is the following: A copperplate is first coated over with a film of bichromated albumen and exposed under a negative; the plate is then washed with cold water, and etched with an alcoholic solution of ferric chloride.

The following details will be sufficient to enable the method to be carried into practice.* One hundred cubic centimeters of albumen are mixed with a solution of two and a half grammes of bichromate of ammonia, in fifty cubic centimeters of water, and, after having been well beaten, the mixture is filtered. A carefully cleaned plate of copper is now coated with the mixture, and after the excess has been well drained off, the plate is dried at a very gentle heat, it being retained in a horizontal position meanwhile. The exposure required is by no means a long one, half a minute in moderate sunshine being sufficient in ordinary cases; but this must, of course, be learned by experience. Instead of developing (washing away the unaltered albumen) in plain water, it is better to use a weak solution of aniline red or magenta dye, as under these circumstances the ground becomes tinted, and the progress of the development can be watched. When the plate has been dried, nothing now remains but to varnish the back and edges with an ordinary black varnish, such as the so-called Brunswick black, and to etch. The etching bath is made by dissolving one part of perchloride of iron in five of alcohol, and ten minutes is generally sufficient time for etching to the required depth.

* T. C. Bolas on "Photo-mechanical Printing."

Major Waterhouse succeeded in perfecting a process of photo-engraving with intaglio plates, his method being a modification of a process previously introduced by Geymet. The process is based upon the reticulation of a Woodbury relief.

A Woodbury relief (see **Woodburytype**) is first developed upon a plate of silvered copper. The relief need not be quite so high as required for the Woodburytype process; ordinary carbon tissue may be used. When the relief has been developed and washed, it is immersed in a solution of potassium dichromate, drained and dusted over with very fine sand previously waxed by heating in an iron pot, and stirring up with a small quantity of wax. The waxed sand is now allowed to remain on the film until quite dry. When dry it is brushed off, and it will be found to have granulated or pitted the gelatine image, the pits being deepest in the thicker parts. The next process is to blacklead the plate, and make a cast in the electrotype bath. This electrotype is used as the printing plate.

Obernetter's "Lichtkupferdruck" is another process. A gelatino-bromide image is made in a film of emulsion rich in silver. This is converted into silver chloride by immersing in a solution of weak potassium dichromate acidified with hydrochloric acid. This silver chloride film is laid on to a copperplate. The chloride of silver becomes decomposed, uniting with the copper and etching it, all the details being reproduced as an intaglio. To assist the action the copperplate is connected to the positive wire of a battery, the negative wire being connected to a carbon plate placed behind the film picture. If the latter be moistened with weak salt and water the etching of the plate proceeds very rapidly.

PHOTO-ETCHING.—See **Photo-engraving.**

PHOTO FILIGRANE.—A process invented and patented by Woodbury. It is briefly a method of producing designs or photographs on paper and other similar materials by pressure, with a photographic relief.

A gelatine relief is first made with carbon tissue specially prepared for this purpose. This has a much thicker coating of gelatine. After sensitizing with potassium dichromate, it is exposed under a positive as in the Stannotype process. After transferring to the support, developing and drying, a hard gelatine relief is obtained. This is laid on to a sheet of paper, and the two passed together through a rolling press, the relief being well rolled into the paper. The result is that the paper body is pressed thinner in some parts than others, the thin parts appearing much lighter. On holding the paper up to the light, a photographic image is seen. The relief can be used a large number of times. By this process many novelties can be produced. Portraits can be pressed into visiting cards, writing paper, etc., designs of all kinds made. It being somewhat similar to the watermark in the bank-notes, it could be used for that purpose, saving considerable expense, with just as sure results, and with much less likelihood of forgery. The process has for some reason or other been abandoned commercially.

PHOTO-GALVANOGRAPHIC PROCESS.—A photo-mechanical process now no longer used, although many of the present secret processes are based upon it. Pretsch's photo-galvanographic process may thus be briefly described. A glass plate was first coated over with gelatine containing potassium dichromate or silver salt and other chemicals. When dry it was exposed under a transparency. After printing it was immersed in cold water to dissolve out the unaltered chromium salt and to cause those parts protected from the light to swell up in proportion to the protection which had been afforded by the transparency. Further, the raised portions were rough and reticulated, the reticulation being coarse or fine in proproportion as the different parts had been protected. The high lights did not, of course, swell at all, and had no grain. The plate thus produced was, of course, an exact reverse of what is required for printing. All that was then necessary was to take an electrotype cast from this relief to obtain the printing plate.

Pretsch produced plates of this description about the year 1868. The Fox-Talbot process was contemporary with Pretsch and somewhat similar.

Neither process was a commercial success, probably owing to its not being in a sufficiently perfect state to render it independent of the help of the engraver for retouching the plates.

PHOTOGASTROSCOPE.—An arrangement for photographing the inside of the stomach. Fig. 332 illustrates the apparatus. At the end is attached a small electric light which lights up the cavity. An image is transmitted through the lens tube to the camera by means of mirrors. The arrangement has also a fine tube, through which air is forced to inflate the stomach. Water is also made to circulate round the electric light.

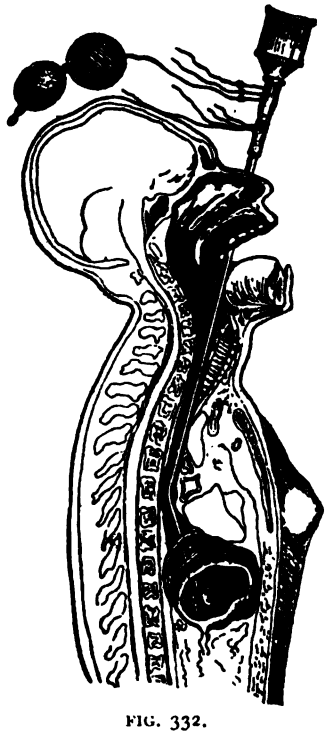

FIG. 332.

PHOTOGENE.—To produce.—The generation of a more or less continued impression or picture on the retina, and the delay in the obliteration of it.

This name was also applied by Gaudin to "any sensitive compound containing iodide of silver with excess of free nitrate."

PHOTOGENIC DRAWING.—An early photographic process described by Fox-Talbot in the year 1839. He used paper impregnated with common salt and sensitized with nitrate of silver. He also substituted potassium bromide for the common salt to get the sensitive surface. Both negatives and positives were made on this paper. Common salt was used as a fixing agent, until the superior action of sodium hyposulphite was discovered by Herschel.

PHOTOGENY.—The same as photography.

PHOTOGRAM.—Term recently adopted by many writers in place of photograph.

PHOTOGRAMMETRY.—Surveying by means of photography.

PHOTOGRAPH ENVELOPE.—An envelope intended for the reception of photographs; to keep clean and protect the surface of the paper. They are usually of some transparent material in order that the subject may be visible without removing the picture.

PHOTOGRAPHIC CHEMICALS.—The following is a list of the most important chemicals used in the various photographic operations, with English, Latin, German and French terms, compiled by C. L. Lochman:

PHOTOGRAPHIC CHEMICALS.

ENGLISH.	LATIN.	GERMAN.	FRENCH.
Acid Acetic	Acidum aceticum	Essigsäure	Acide acetique.
" " Glacial	Acidum aceticum glaciale	Eisessig	Vinaigre glacial.
" Chromic	Acidum chromicum	Chromsäure	Acide chromique.
" Citric	Acidum citricum	Citronensäure	Acide citrique.
" Gallic	Acidum gallicum	Gallussäure	Acide gallique.
" Hydrochloric	Acidum hydrochloricum	Salzäure	Acide chlorhydrique.
" *Muriatic*			
" Nitric	Acidum nitricum	Salpetersäure	Acide nitrique (azotique).
" Oxalic	Acidum oxalicum	Oxalsäure	Acide oxalique.
" Pyrogallic; Pyrogallol.	Acidum pyrogallicum	Pyrogallussäure; Pyrogallol.	Acide pyrogalique.
" Tartaric	Acidum tartaricum	Weinsteinsäure	Acide tartarique,
" Sulphuric	Acidum sulphuricum	Schwefelsäure	Acide sulfurique.
" Tannic; Tannin	Acidum tannicum	Gerbsäure	Acide tannique.
Alcohol, Ethyl	Alcohol	Weingeist	Alcool.
Alcohol, Wood	Alcohol methylicum	Holzgeist	Alcool methylique.
Alum, Ammonia	Aluminii et ammonii sulphas	Ammoniak-Alaun	Sulphate d'alumine et d'ammoniaque.
Alum, Chrome	Chromii et potassii sulphas	Chrom-Alaun	Alun chromi-potassique.
Alum, Potassa	Aluminii et potassii sulphas	Kali-Alaun	Sulfate d'alumine et de potasse.
Ammonium Bichromate	Ammonii bichromicum	Doble chromsaures Ammon.	Bichromate d'ammoniaque.
Ammonium Nitrate	Ammonii nitras	Ammoniumnitrat	Azotate d'ammionaque.
Benzin	Benzinum	Petroleumbenzin	Benzine.
Benzol	Benzolum	Benzol	Benzole.
Bromine	Bromum; Brominium	Brom	Brome.
Cadmium Bromide	Cadmii bromidum	Kadmiumbromid; Bromkadmium.	Bromure de cadmium.
Cadmium Iodide	Cadmii iodidum	Kadmiumjodid; Jodkadmium.	Iodure de cadmium.
Calcium Bromide	Calcii bromidum	Bromcalcium	Bromure de calcium.
" Carbonate	Calcii carbonas	Calciumcarbonat	Carbonate de calcium.
" Iodide	Calcii iodidum	Jodcalcium	Iodure de calcium.
Chloroform	Chloroformum	Chloroform	Chloroforme.
Collodion	Collodium	Collodion	Collodion.
Dextrin	Dextrinum	Stärkegummi	Dextrine.
Eikonogen	Eikonogen	Eikonogen	Eikonogen.
Ether (Sulphuric)	Aether (sulphuricus)	Aether; Schwefeläther	Ether sulfurique.
Gelatin	Gelatina	Gelatin	Gelatine.
Glycerin	Glycerinum	Glycerin	Glycerine.
Gold	Aurum	Gold	Or.
" Chloride	Auri Chloridum	Goldchlorid	Chlorure d'or.
" and Sodium Chloride	Auri et sodii chloridum	Natriumgoldchlorid	Chlorure d'or et de sodium.
Gum Arabic	Gummi Arabicum	Arabisches Gummi	Gomme Arabique.
Gum Sandarac	Sandaraca	Sandarak	Sandaraque.
Gum Shellac	Ressina lacca	Lack; Gummilack	Laque.
Hydrochinon; Hydroquinon.	Hydrochinonum	Hydrochinon	Hydrochinon.

Iodine	Iodum ; Iodinium	Jod	Iode.
Iron Sulphate	Ferri sulphas	Ferrosulfat	Sulfate de fer.
Lithium Bromide	Lithii bromidum	Bromlithium	Bromure de lithium.
" Iodide	Lithii iodidum	Jodlithium	Iodure de lithium.
Magnesium Bromide	Magnesii bromidum	Brommagnesium	Bromure de magnesium.
" Iodide	Magnesii iodidum	Jodmagnesium	Iodore de magnesium.
" Sulphate	Magnesii sulphas	Magnesiumsulfat	Sulfate de magnesie.
Mercury Bichloride	Hydrargyri bichloridum	Aetzendes Quecksilber chlorid. Also "sublimat."	Deutochlorure de mercure.
Oil of Lavender	Oleum Lavandulæ	Lavendelöl	Essence de Lavand.
Oil of Turpentine	Oleum Terebinthinæ	Terpintinöl	Essence Terebinthine.
Platinum Chloride	Platini chloridum	Platinchlorid	Perchlorure de platine.
Platino-Potassium Chloride.	Platini et Potassii chloridum	Kali-Platinumchlorid	Chlorure de platinum et de potassium.
Potasso, Sulphurated ; Silver of Sulphur.	Potassa sulphurata	Schwefelleber	Sulfure de potasse.
Potassium Bichromate	Potassii bichromas	Kaliumbichromat	Bichromate de potasse.
" Bromide	Potassii Bromidum	Kaliumbromid	Bromure de potassium.
" Carbonate	Potassii carbonas	Kaliumcarbonat	Carbonate de potasse.
" Cyanide	Potassii cyanidum	Cyankalium	Cyanure de potassium.
" Ferricyanide	Potassii ferricyanidum	Ferridcyankalium	Ferricyanure de potassium.
" Ferrocyanide	Potassii ferrocyanidum	Ferrocyankalium	Ferrocyanure de potassium.
" Hydrate, Potassa.	Potassii hydras ; Potassa	Aetzkali	Potasse caustique.
" Iodide	Potassii iodidum	Jodkalium	Iodure de potassium.
" Oxalate, neutral.	Potassii oxalas	Kalium Oxalat, neutrales	Oxalate de potasse neutre.
" Sulphite	Potassii sulphis	Kaliumsulfit	Sulfite de potassium.
" Sulphocyanide.	Potassii sulphocyanidum	Kalium sulfocyanat; Rhodankalium.	Sulfocyanure de potassium.
Pyroxylin ; Gun Cotton	Pyroxylinum	Collodionwolle ; Schiessbaumwolle.	Pyroxyle ; Fulmi-coton.
Silver	Argentum	Silber	Argent,
" Nitrate	Argenti nitras	Silbernitrat	Nitrate d'argent.
" Oxide	Argenti oxidum	Silber Oxyd	Oxyde d'argent.
Sodium Acetate	Sodii acetas	Natriumacetat	Acetate de soude.
" Biborate ; Borax.	Sonii biboras	Natrium borat ; Borax	Borate de soude.
" Bicarbonate	Sodii bicarbonas	Natriumbicarbonat	Bicarbonate de soude.
" Bromide	Sodii bromidum	Bromnatrium	Bromure de sodium.
" Carbonate	Sodii carbonas	Natriumcarbonat	Carbonate de soude.
" Chloride	Sodii chloridum	Chlornatrium	Chlorure de sodium.
" Citrate	Sodii citras	Natriumcitrat ; Citronensaures Natron.	Citrate de soude.
" Hydrate ; Soda	Sodii hydras ; Soda	Aetznatron	Soude caustique.
" Hyposulphite or Thiosulphate.	Sodii hyposulphis	Unterschwefligsaures Natron.	Hyposulfite de soude.
" Iodide	Sodii iodidum	Jodnatrium	Iodure de sodium.
" Sulphite	Sodii sulphis	Natrium sulfit	Sulfite de soude.
" Tungstate	Sodii tungstas	Wolfraumsaures Natron	Tungstate de soude.
Starch	Amylum	Stärke ; Stärkmehl	Amidon.
Strontium Bromide	Strontii bromidum	Bromstrontium	Bromure de strontium.
" Chloride	Strontii chloridum	Chlorstrontium	Chlorure de strontium.
" Iodide	Strontii iodidum	Jodstrontium	Iodure de strontium.
Tannin, see Tannic Acid.			
Turpentine, Crude or White.	Terebinthina communis	Geweiner Terpentin	Terbenthine commune.
Uranium Bromide	Uranii bromidum	Bromuranium	Bromure d'uranium.
Uranium Nitrate	Uranii nitras	Salpetersaures Uranoxyd	Nitrate d'urane.
Water, Distilled	Aqua destillata	Destillirtes Wasser	Eau distillée.
Water of Ammonia	Aqua ammoniæ	Salmiakgeist ; Ammoniak-Flüssigkeit.	Eau d'ammoniaque.
Zinc Bromide	Zinci bromidum	Zinkbromid ; Bromzink	Bromure de zinc.
Zinc Chloride	Zinci chloridum	Chlorzink	Chlorure de zinc.
Zinc Iodide	Zinci iodidum	Zinkjodid ; Jodzink	Iodure de zinc.

Under *formula* will be found another list giving the formulæ and molecular weights

It is very essential in most photographic processes that the chemicals be perfectly free from impurities, as by the presence of small quantities of foreign matter the success of a process is often ruined entirely. The following list* of the impurities occasionally found in the various chemicals, and the means of testing same, will be found useful :

Substance.	Impurities Possibly Present.	Tests.
Ammonia	Carbonic acid	Renders lime-water milky.
	Dissolved solid matter	Residue left on evaporation.
	Chlorides	After acidulating with nitric acid, it gives a precipitate with silver nitrate, which, after washing, is readily soluble in ammonia, and re-precipitated by nitric acid.
	Sulphates	After acidulating with nitric acid, it gives a precipitate with barium nitrate.
	Lime	A white precipitate with oxalate of ammonium.
	Lead is often present, derived from the action upon flint glass bottles.	Black precipitate with sulphuretted hydrogen.

Substance.	Impurities Possibly Present.	Tests.
Nitric Acid.....	Traces of sulphuric acid.....	After dilution it gives a precipitate with barium nitrate.
	Chlorides.....	After dilution it gives a precipitate with silver nitrate.
	Peroxide of nitrogen.....	The acid is yellow.
	Iodine may be present if the acid be prepared from sodium nitrate.	After dilution and cooling it gives a blue color with starch paste or mucilage.
Hydrochloric Acid.....	Free chloride.....	Liberates iodine from solution of potassium iodide. See also chlorides, nitric acid.
	Sulphuric Acid.....	As above for nitric acid.
	Perchloride of iron.....	Yellow color. Brown precipitate with ammonia added till it smells slightly.
Hydrochloric Acid.....	Arsenic.....	Marsh's test.
	Some yellow samples contain no iron, but an organic salt, and give an alkaline ash on ignition of the residue after evaporation.	Reinsch's test; a small piece of copper foil becomes coated on boiling in dilute acid.
Sulphuric Acid.....	Bisulphate of potassium.....	Residue on evaporation.
	Sulphate of lead.....	Milkiness on dilution. May be completely freed from lead by diluting with three or four times as much water, and allowing to settle.
	When sold as pure, it invariably contains a trace of iron. Common acid is also liable to contain arsenic, selenium, thallium, and many other substances.	No easy test can be given, as the substances are so numerous; some of them volatile, and most require separation from the acid before detection.
	Organic matter, as a piece of straw in a carboy of acid.....	Gives a brown color to the acid.
Acetic Acid.....	Water.....	Does not solidify when cooled to 17° C. (53° F.)
	Sulphurous and hydrochloric acids	White precipitate with silver nitrate.
	Aldehyde, or volatile tarry matter.	Blackens in the light after adding silver nitrate.
	Organic sulphuric acid.....	Smell of garlic.
Citric Acid.....	Tartaric acid.....	Strong solution of potassium acetate added to a strong solution of the acid will deposite white crystalline bitartrate.
Pyrogallic Acid.....	Metagallic acid.....	Black residue insoluble in water.
Silver Nitrate	Free nitric acid.....	Reddens litmus paper (neutral silver nitrate does not affect litmus).
Potassium Carbonate..	Chlorides and sulphates.....	Same as for ammonia.
Potassium Iodide.....	Potassium carbonate.....	A strong solution is alkaline to test paper.
	Sulphates and chlorides.....	Same as for ammonia.
	Potassium iodate.....	A pretty strong solution becomes yellow from liberation of iodine on addition of dilute sulphuric acid, or, better, a strong solution of citric acid.

TABLE OF EQUIVALENT QUANTITIES OF SOME HALOIDS USED IN PHOTOGRAPHY.

Calculated for the Anhydrous and Dry Salts.

By A. B. Aubert, Professor of Chemistry, Maine State College, Orono, Me.

† Equivalent Quantities of Various Chlorides Used in Photography.

Sodium Chloride.	Potassium Chloride.	Ammonium Chloride.	Lithium Chloride.	Cadmium Chloride.
1	1.275	0.914	0.726	1.564
0.784	1	0.717	0.569	1.226
1.093	1.394	1	0.794	1.710
1.376	1.755	1.258	1	2.152
0.639	0.818	0.584	0.464	1

† Equivalent Quantities of Various Bromides Used in Photography.

Bromine.	Ammonium Bromide.	Potassium Bromide.	Sodium Bromide.	Cadmium Bromide + 4 Equi. Water.	Zinc Bromide.
1	1.225	1.488	1.287	2.150	1.406
0.816	1	1.214	1.055	1.754	1.147
0.672	0.823	1	0.865	1.445	0.945
0.777	0.952	1 156	1	1.671	1.092
0.465	0.570	0.692	0.599	1	0.654
0.711	0.871	1.058	0.915	1.529	1

* Compiled by G. M. Jones for the "American Annual of Photography."
† Translated and partly recalculated from the "Agenda du Chimiste."

† Equivalent Quantities of Various Iodides Used in Photography.

Iodine.	Ammonium Iodide.	Potassium Iodide.	Sodium Iodide.	Cadmium Iodide.	Zinc Iodide.
I	1.142	1.307	1.181	1.441	1.255
0.876	I	1.145	1.035	1.262	1.099
0.765	0.874	I	0.903	1.102	0.960
0.847	0.967	1.107	I	1.220	1.063
0.694	0.793	0.907	0.820	I	0.871
0 797	0.910	1.042	0.941	1.148	I

† Equivalent Quantities of Various Silver Salts Used in Photography.

Silver (Metallic).	Nitrate.	Chloride.	Bromide.	Iodide.
I	1.574	1 328	1.741	2.176
0.6353	I	0.844	1.106	1.382
0.7523	1.184	I	1.310	1.638
0.5744	0.904	0.763	I	1.250
0.4595	0.723	0.610	0.800	I

† Equivalent Quantities of Various Gold Salts Used in Photography.

Gold (Metallic).	Chloride.	Double Chloride of Gold and Potassium.	Double Chloride of Gold and Sodium.
I	1.542	2.1048	2.0229
0.6485	I	1.3645	1.3119
0.4751	0.7326	I	0.9611
0.4943	0.7623	1.0405	I

PHOTOGRAPHIC CHEMISTRY.—The number of chemical changes that take place in photographic operations is so great that it will only be possible to mention the most important. The process that is now almost universally adopted is the gelatino-bromide dry plate process. This has taken the place of a large number of processes and improvements, starting with the Daguerreotype process. In this method of obtaining photographic images a sensitive plate was prepared by exposing a silvered tablet to the action of vapor of iodine, which combines with the metallic silver to form silver iodide, thus:

$$Ag_2 + I_2 = 2AgI.$$

Subsequently bromine vapor was used with iodine. On exposing the plate thus prepared in the camera a latent image was formed, which was made to appear by the vapor of mercury. Sodium hyposulphite was afterwards discovered as a fixing agent.

After the Daguerreotype came the colotype or Talbotype process, named after the inventor, Fox-Talbot. In this paper was used as the support for the image. It was prepared by first floating on a solution of silver iodide, and then washing slightly. When required for use this paper was excited with gallic acid and aceto-nitrate of silver brushed over it. It was then exposed in the camera, and afterwards developed with the same substances.

Then came the collodion process of Scott Archer, still employed for special work, as in photo-mechanical printing. In this process glass plates were first coated with collodion (a solution of gun-cotton dissolved in ether and alcohol) containing an iodide salt,* and then sensitized by immersion in a bath containing a silver nitrate solution. The iodide combining with the silver formed silver iodide, thus:

$$AgNO_3 + CdI = AgI + CdNO_3.$$

The sensitized plates, after exposure to the image in the camera, were developed with pyrogallic acid with either acetic or citric acids. The negatives thus obtained were fixed with potassium cyanide or sodium hypo-sulphite.

We now come to the modern *dry* plate process, so called to distinguish it from the collodion process, in which the plates were exposed in the *wet* state. The material which forms the sensitive surface of the plate is silver bromide, in some cases mixed with chloride and iodide, and held in position by a gelatine.

Silver bromide is a heavy, almost insoluble, white precipitate, obtained by adding a solution of potassium or ammonium bromide to one of silver nitrate. The white flakes of silver bromide thus formed fall to the bottom of the vessel, and in this form the compound is practically useless for photographic purposes. If, however, a fluid of a viscous nature is used, the silver bromide will not fall to the bottom, but remain in suspension, and in this form is termed an emulsion, which can be used for coating plates or paper. The usual method is to dissolve a quantity of gelatine in warm water, and mix with it the ammonium bromide. The silver nitrate is then

* Cadmium iodide was usually employed. † Translated and partly recalculated from the "Agenda du Chimiste."

gradually added, and a white silver bromide emulsion is produced. The change is thus represented :

$$AgNO_3 + (NH_4)Br = AgBr + (NH_4)NO_3.$$

Now, it must be noted that silver bromide is sensitive to the action of light, so that the addition above described in making the emulsion must, of course, be performed in a non-actinic light.

When the bromide is added to the silver, a certain quantity will combine with it, and no more. A simple calculation tells us that according to the equation 119 parts by weight of potassium bromide will combine with 170 parts by weight of silver nitrate.*

The sensitiveness of the emulsion is increased by boiling it. This has the effect of converting the insensitive very fine reddish silver bromide into a very sensitive coarse blue substance.

We have shown that in mixing the bromide with the silver, silver bromide and ammonium nitrate are formed. The next process is to wash the latter soluble compound from the emulsion. This is done by breaking the gelatine emulsion up into small shreds and washing well in several changes of water ; besides the potassium or ammonium nitrate, any soluble bromide is also washed away, leaving the insoluble sensitive silver bromide in the gelatine. It is then remelted, and glass plates coated with it and dried are termed gelatine dry plates.

These dry plates are, when required, placed in the camera and exposed to the image formed by the lens. The effect of this is that a *latent* or invisible image is impressed on the film of the plate, which may be afterwards rendered visible by development. What is the change that occurs to produce this effect? Chemists and scientists are as yet divided upon the subject.

The theory that till recently has met with general acceptance, and which Captain Abney gives in his work, is that the silver bromide is reduced by light to sub-bromide (Ag_2Br). The formation of this sub-bromide depends, of course on the active rays from different parts of the object.

Another theory is that electricity is sufficient to account for the formation of the latent image.†

C. J. Leaper says ‡ that the weight of indirect evidence (necessarily indirect from the difficulties surrounding the problem to be solved) seems to point to the formation by light of silver oxybromide $Ag_2O.2AgBr$. It is well known that bromine is evolved during exposure,§ and on the assumption that oxygen is at the same time absorbed, we may express the change by the following equation :—

$$4AgBr + O = Ag_2O.2AgBr + Br.$$

Carey Lea, in America, has recently published his investigations in what he terms the "photo-salts of silver," which he has prepared, and which he states are producible from the haloid salts of silver (the chloride, bromide and iodide) by the action of light, as well as by purely chemical means, his photo-bromide consisting of silver sub-bromide in combination with silver bromide, the sub-bromide forming but a small portion of the whole. This photo-bromide is insoluble in strong nitric acid, whilst the sub-bromide itself is very soluble in it, and this theory receives strong confirmation in other ways ; it appears to be the one most probably correct.‖

The latent image produced, we have next to consider the action of the developing agent. All developers are energetic oxygen absorbers, it being upon this property that their power of developing is based. The commonest developer is the pyrogallic acid.

Pyrogallic acid is an erroneous term for what is not an acid at all, but more correctly pyrogallol—its chemical name is tryhydroxy-benzene. It is a powerful and greedy absorber of oxygen. It is only active in an alkaline medium. Combined with ammonia, its action on the silver sub-bromide is to reduce the silver to the metallic state, ammonium bromide being formed thus—

$$C_6H_4(OH)_3 + 2Ag_2Br + 2(NH_4)OH = 2NH_4Br + 2Ag_2 + H_2O + (C_6H_4OH_3 + O)$$

When ammonium bromide is used with this developer as a restrainer, its action appears to consist in diminishing the amount of silver sub-bromide capable of being dissolved by the ammonia. If strong ammonia is used more silver bromide is dissolved. If strong pyro solution is used a more rapid reduction of the bromide will take place, resulting eventually in fog.

Another developer largely employed is the ferrous oxalate, composed of ferrous sulphate, mixed with potassic oxalate, forming ferrous oxalate and potassic sulphate, the ferrous oxalate being dissolved by the excess of potassic oxalate.

$$K_2C_2O_4 + FeSO_4 = FeC_2O_4 + K_2SO_4.$$

This also acts as a powerful reducing agent, becoming oxidized to ferric salt.

$$6FeC_2O_4 + 6Ag_2Br = 6Ag_2 + Fe_2Br_6 + 2Fe_2(C_2O_4)_3.$$

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* In practice, however, a larger quantity of bromide is taken than the equation represents, because it prevents the silver nitrate from combining with the gelatine, and for other reasons.

† "The Chemistry of Photography," by J. C. Wiggin.

‡ "The Chemistry of a Dry-plate."

§ If dry plates are exposed to the light, a distinct smell of bromine can be detected.

‖ J. C. Wiggin.

Hydroquinone or paradihydroxybenzene is another favorite developing agent. It is closely allied to pyro, its formula being $C_6H_4(OH)_2$. On development it becomes oxidized to quinone.

$$C_6H_4(OH)_2+O=C_6H_4O_2+H_2O.$$

Besides the various reducing agents used as developers, the alkalies—ammonia potash and soda and their carbonates—are used as accelerators. Ammonia is most energetic, but is liable to produce stains.

The latent image having been developed and become visible, the next operation is to fix the image, or, in other words, to make it permanent by dissolving out the silver bromide unacted upon by the light. If this were not done it will be obvious that the image would be reduced on exposure to the light. The fixing salt usually employed is sodium hyposulphite. Potassium cyanide, common salt, ammonia, and other salts can also be employed. Hyposulphite of soda, or, as it is more correctly termed, sodium thiosulphate, is considered to be sodium sulphate Na_2SO_4, in which one atom of oxygen has been replaced by sulphur.

$$Na_2S_2O_3.$$

The action of this salt upon the photographic film is one of double decomposition.

$$Na_2S_2O_3+2AgBr=2NaBr+Ag_2S_2O_3.$$

The silver hyposulphite formed combines with excess of hypo forming the soluble double salt.

$$Ag_2S_2O_3,\ 2Na_2SO_3.$$

If the hypo is not in excess another double salt is formed.

$$Ag_2S_2O_3.Na_2O_3.$$

This salt is almost insoluble, and is with difficulty eliminated from the film. The importance of having plenty of hypo in the bath will be at once obvious.

After fixing, the plate is thoroughly well washed to eliminate all soluble matter. A clearing bath of acid and alum is sometimes applied. Before this application, however, it is absolutely necessary that all the hyposulphite be thoroughly eliminated from the film, otherwise it will be decomposed, the following reaction taking place:

$$Na_2S_2O_3+2HCl=H_2O+SO_2+2NaCl.$$

If the negative image be too thin for the subsequent manipulation, it is intensified. This is accomplished either by increasing the deposit of silver, or by partial substitution of another metal for it. The chemistry of intensification is given under **Intensification** (*q.v.*).

If, on the contrary, the negative image is too dense for the subsequent process, it is reduced by the application of a solution of potassium ferricyanide and hypo. The action that takes place here is in all probability the reduction of the ferricyanide ($K_6Fe_2Cy_{12}$) to ferrocyanide ($K_4Fe Cy_6$); the oxygen formed, combining with the silver of the image, would, as silver oxide (Ag_2O), be removed by the hypo.

The negative completed, we have next to consider the methods of making the positive print. The most generally employed method is that known as albumenized paper printing. Ordinary paper is coated over with albumen containing ammonium chloride. When dry this is floated face downwards on a solution of silver nitrate. The reaction that takes place is usually described thus:

$$AgNO_3+(NH_4Cl)=AgCl+NH_4NO_3.$$

In addition to the silver chloride formed, free silver nitrate is also present. Further, a combination of the silver with the albumen also takes place, forming albuminate of silver. The principle of the process is this—silver chloride, if exposed to the light, in contact with organic matter, is darkened to sub-chloride,

$$2AgCl=Ag_2Cl+Cl.$$

Chlorine is liberated, which, if silver nitrate be present, combines with its silver, forming silver chloride again, and free nitric acid.

The silver albuminate present is reddened on exposure to the light to a sub-oxide (Ag_4O). This when acted upon by the hypo is converted into metallic silver and silver oxide, which is to a great extent dissolved. The hypo also removes the silver sub-chloride, leaving a certain amount of metallic silver from it.

Positive prints upon albumenized paper have usually a disagreeable color. For this reason toning is resorted to. It consists essentially in the deposition of gold or other metal upon the silver of the print. The free nitrate of silver is first removed from the paper by washing, otherwise gold nitrate and silver chloride would be formed by double decomposition. The toning bath usually consists of a gold chloride solution, and any salt in which a fixed alkali is combined with a weak acid. Acetates and alkaline carbonates are capable of precipitating gold from neutral solution in the presence of organic matters. With the acetate bath the following represents the change that takes place:

$$2AuCl_3+NaC_2H_3O_2=Au_2+NaC_2Cl_3O_2+3HCl.$$

Phosphate, biborate, bicarbonate, and many other salts of sodium and potassium may be used, the action being similar in each case, *i.e.*, to deposit the gold on the silver particles of the print.

Besides gold, other metals, as uranium, platinum, etc., may be used.

In printing with gelatino-chloride papers the chemical action is somewhat similar, except that a quantity of a citrate is added to a film, forming a compound of silver citrate, and doing away with the free nitrate. Further, gelatine is the vehicle used for holding the sensitive salt in suspension, so that the silver albuminate is not formed. Prints upon gelatino-chloride paper are considered to be more permanent than those made upon albumenized paper.

In fixing prints the chemical change is very similar to that which takes place in fixing the dry plate, and which has already been described. The soluble double salts are formed Owing to the decomposing action of acids upon hypo it is advisable that the fixing bath be kept alkaline.

It is very important that after fixing, the hyposulphite of sodium be thoroughly dissolved from the film. Potassium sulphocyanide may also be used as a fixing agent. It is not superior to hypo, however, and is a violent poison.

The chemical action of bromide paper is the same as with bromide plates. The same kind of emulsion is usually employed, it being spread on to paper instead of glass.

Alpha paper is similar to bromide paper, except that a chloride is used instead of a bromide, chloride of silver being formed.*

In platinum printing the salts of platinum are reduced, that is to say, the metal is set free by ferrous salts, and ferric salts when exposed to light become reduced to ferrous.

The reactions that may be stated to take place are thus represented:

$$Fe_2 3C_2O_4 = 2FeC_2O_4 2CO_2.$$
$$3K_2PtCl_4 + 6Fe_2C_2O_4 = Fe_2Cl_6 + 2Fe_2 3C_2O_4 + 6KCl + 3Pt.$$
$$Fe_2 3C_2O_4 + 3K_2C_2O_4 = 2Fe^{III}K_3 3C_2O_4.$$

The carbon process, and the basis of the majority of the photo-mechanical processes, depends upon the sensitiveness of the dichromates to light. In the carbon process the paper is first coated with a solution of pigmented gelatine. This is floated on a solution of potassium or ammonium dichromate. In presence of gelatine these dichromates become reduced by the action of the light, a portion of their oxygen combines with the gelatine, causing it to become quite insoluble. Thus:

$$2K_2Cr_2O_7 = 2K_2CrO_4 + CrO_3 + O_3.$$

When hot water is applied the portions unacted upon by the light which remain soluble are washed away, leaving the image in pigmented gelatine.

PHOTOGLYPHIC ENGRAVING.—A process of photo-etching invented by Fox Talbot. A metal plate was coated with gelatine, sensitized with potassium dichromate, and exposed to light under a negative. It was then dusted with finely powdered copal and warmed until this melted. When cold it was covered with suitable etching fluid which soaked through the portions of the film unacted upon by light, and attacked the plate underneath.

PHOTOGLYPHY.—See **Photo-engraving.**

PHOTOGLYPTIE.—The French name given to the Woodburytype process.

PHOTOGRAM.—A photographic image, a photograph.

PHOTOGRAPH.—A representation or picture of an object obtained by means of photography.—For the law of copyright in photography, see **Copyright.**

PHOTOGRAPHER.—One who takes a picture or likeness by means of photography. Many attempts have been made of late to draw a clear distinction between an amateur and a professional photographer. Correctly speaking, an amateur is one who follows the occupation merely for love, and without any attempt at making profit by means of same, while a professional is dependent either partly or wholly upon the art for his means of livelihood. Many are of the opinion that directly an amateur photographer sells or receives any money for his work he ceases to be an amateur and becomes a professional. The question then raised is this: If an amateur accept money for his work to partly recompense him for his expenses in connection therewith, can be no longer be considered an amateur? Provided he does not rely upon photography at all for his income, he should be classed as an amateur. (See **Amateur**)

PHOTOGRAPHIC COPYRIGHT.—See **Copyright.**

PHOTOGRAPHIC GUN.—A small instantaneous camera used in the same way as an ordinary gun. It possesses a rapid lens with an instantaneous shutter fitted into the barrel, with an

* A small quantity of a bromide is also used generally.

arrangement for focusing. A cylinder contains 18 plates 1½ in. diameter, which are brought one after the other into position.

PHOTOGRAPHIC OPTICS.—See **Optics, Lens, etc., etc.**

PHOTOGRAPHIST. —A photographer.

PHOTOGRAPHY.—Many attempts have been made to trace the art of photography. A lens has been found in the ruins of Ninevah, a city destroyed a thousand years before Christ. Some authorities assert that this must have been used only as an ornament by the women of the time, although it seems hardly possible that they should not have discovered the fact that images of objects could be obtained with it. The following is a slight resumé of the progress of photography, although the art itself cannot be said to have been discovered till the Daguerreotype process.

1556. Fabricius published a book on metals in which is noted that chloride of silver, or *luna cornea*, as it was then termed, darkened on exposure to the light.

1590. The camera obscura was invented by the Italian pnilosopher, Baptista Porta.

1727. J. H. Schulze obtained copies of writing in sunshine upon surfaces prepared with a mixture of a nitrate of silver solution with chalk.

1779. Scheele showed that violet light was most active in changing silver chloride. His results were confirmed by Senebier, who wrote that in fifteen seconds the violet rays blackened silver chloride as much as the red rays did in twenty minutes.

1774. Scheele discovered the cause of the darkening of silver chloride exposed to the light. He proved the effect upon it was to decompose it and cause it to give up some or all of its chlorine. He proved this by exposing it to light under water.

1795. Lord Brougham suggested in a communication to the Royal Society* the possibiltiy of obtaining pictures upon ivory rubbed with silver nitrate and exposed to the camera.

1802. Thos. Wedgwood (fourth son of the great potter) and Humphry Davy read a paper at the Royal Institution on copying paintings done on glass, and making profiles by means of silver nitrate. Davy discovered that chloride was more sensitive to light than nitrate of silver, and that white leather was superior to paper. These experimenters afterwards abandoned their researches for want of something that would fix the impressions thus obtained, and prevent them from further darkening when exposed to light.

1810. Seebeck is stated to have observed that when the solar spectrum was projected upon moist chloride of silver a faint impression of the natural colors was produced.

1812. Iodine was discovered by Courtois.

1813. About this time Joseph Nicephore de Niepce commenced his experiments, which resulted in the discovery of the bitumen process of photography. He coated metal plates with asphaltum or bitumen of Judea, and exposed them in the camera for several hours. The parts unaffected by the light remained soluble, and were dissolved away with oil of lavender.

1819. Sir John Herschel drew attention to the hyposulphites and the solvent power of the akaline hyposulphites upon chloride of silver.

1824. Daguerre commenced his experiments on similar lines to Niepce.

1826. Bromine was discovered by Balard. Daguerre became acquainted with Niepce.

1827. Niepce was refused a hearing at the Royal Society because he would not reveal the details of the process.

1829. Niepce and Daguerre entered into a partnership, which was continued after the death of Niepce, his son, Isidore, taking the place of his father.

1833. Niepce, the elder, died. Daguerre continued his work. His experiments in using iodine to stain the surface of the silver plates led to the invention of the Daguerreotype process.

1834. Fox Talbot commenced his researches, and in 1839 showed several pictures stated to have been made in the camera in 1835.

1848. Daguerre attempted to form a company to work his new process, the Daguerreotype. The Parisian public was perfectly incredulous, and the shares were not taken up. He then explained his process to the eminent French astronomer and physicist, Arago. On the latter's recommendation to the French Government Daguerre was awarded a life pension of 6,000 francs, and Isidere Niepce one of 4,000 francs per annum, on condition that the invention was published to the world.

1839. Notwithstanding this, a patent was taken out by Daguerre in England, in this year, five days before it was publicly announced at Paris.

In the same year Fox Talbot described his method of "Photogenic drawing." He soaked paper in a weak solution of common salt, and then brushed one side twice over with silver nitrate. Both negatives and positives were produced. The images were fixed with common salt.

Herschel pointed out the superiority of sodium hyposulphite as a fixing agent.

J. B. Reade used an infusion of nutgalls to render silver nitrate on paper more sensitive to light.

* This does not appear in the published paper; Lord Brougham stated that he did make the suggestion, but it was eliminated from the published report by the secretary.

Mungo Ponton discovered the peculiar properties possessed by potassium bichromate. He found that if paper be soaked in a solution of potassium bichromate and dried it was changed by the action of light, the chromium compound produced being insoluble.

1841. Fox Talbot patented his calotype process, which was afterwards disputed by J. B. Reade on the grounds of his previous discovery. In Talbot's process iodide of silver was used on paper. This, when required for use was brushed over with a gallo-nitrate of silver solution. The image after exposure was hardly visible but required to be developed. This was accomplished by brushing the paper over with more of the solution.

In this year Petzval invented his famous portrait lens, which was constructed by Voigtlander, and Claudet patented the use of colored media for illuminating the dark room, which was previously quite dark.

1842. Herschel described his methods of printing with salts of iron.

1844. Robert Hunt recommended ferrous-sulphate as a developing agent.

1848. Niepce de St. Victor introduced the albumen process. Glass was coated with albumen containing potassium iodide and sensitized in a silver nitrate bath.

1849. A Frenchman, Gustave le Gray suggested the use of collodion for photographic purposes.

1851. Scott Archer introduced the collodion process.

1852. Fox Talbot invented a process of steel engraving by the action of light. This he termed photoglyphy or photoglyphic engraving.

1854. Messrs. Spiller and Crookes introduced a moist collodion process.

1855. A French scientist, Dr. Taupenot, published his collodion albumen dry plate process, which found much favor.

1861. Major Russell published his tannin process.

1864. Sayce and Bolton published an account of a collodion emulsion process.

In 1871. Dr. R. L. Maddox used gelatine in place of collodion and from this sprang the present process of photographing with gelatine dry plates. It was not, however, until many years later that the advantages of gelatine over collodion were fully recognized.

This may be considered as a brief summary of the principal events that led up to the now almost universally employed dry plate process. The wet collodion process, however, is still worked in many establishments for special work where rapidity is not essential, and where brilliancy and depth of contrast are desirable.

PHOTOGRAPHY, APPLICATIONS OF.—The introduction of the modern dry-plate process, and consequently the reduction of the time of exposure to fractions of a second, has caused photography to be of great and wonderful assistance to nearly all the modern arts and sciences. Perhaps the science that has mostly benefited has been astronomy.

Astronomy.—This may be easily explained. The sensitiveness of the eye is very limited. A star placed at such a distance that with the most powerful telescope we possess it is still imperceptible will always remain invisible, but with the photographic camera it is different. By greatly prolonging the exposure, this tiny invisible ray of light slowly but surely acts upon the sensitive plate, and after a sufficient length of time (it may require hours) it reveals its image. When we glance up at the heavens on a starry night we see some thousands of stars visible to the naked eye; with the assistance of a powerful telescope we see thousands more, but by exposing a photographic dry plate for some length of time we become aware of the existence of many hundreds more of these heavenly bodies, more appearing the longer the plate is exposed. The chemical plate possesses two principal advantages over the eye. First it is sensitive to rays utterly powerless to produce any visual effect, and next it can accumulate impressions almost indefinitely, it being possible to photograph objects so faint as to be perfectly hidden from our vision. By this means only may we eventually learn whether a blank space in the sky truly represents the end of the stellar universe, or whether farther and farther still, worlds shine beyond veiled in the obscurity of immeasurable distance. Photographs of the stars were made as early as 1850 by Whipple, of Boston, and since then many thousands have been made of every region of the heavens. A complete chart is now being undertaken. For this purpose about 14,000 plates will have to be exposed from all parts of the earth, and these plates will be so arranged that when correctly placed they will form a complete map.

Some idea of the increased astronomical knowledge that has been gained by the aid of photography may be had from the fact that in Cygnus 170 stars had been carefully mapped out by the old laborious process. A photograph made recently revealed the existence of over 7,000 stars. With regard to lunar and solar photography our astronomers have not been behind. A solar Daguerreotype was made at Paris as early as 1845. In 1857 De la Rue was commissioned by the Royal Society to construct an instrument specially for photographing the sun at Kew Observatory. This instrument was used to make solar pictures or photographic records of the solar condition, and was continued for over fourteen years. For some time it has been asserted that the spots on the sun have a regulating effect upon this earth. Dr. Zeyer, of Prague, claims that by means of photographs of these solar spots he is able to predict by more than twenty-four hours the approach of tempests, hurricanes, earthquakes, etc. The transit of Venus, comets,

nebulæ, eclipses, etc, have all received the attention of the camera. See **Astronomical Photography.**

Medicine. The physician is gradually recognizing the claims of photography to his attention. He is now able to photograph the eye by a flash of light so that the pupil, being previously in the dark, is dilated to its utmost, and has no time to contract before the deed is done and the image permanently recorded. Cameras are now being constructed for photographing the interior of the abdomen.* Valuable photographs, too, have been made of peculiar diseases, natural phenomena, etc., which cannot but be of great use to the medical student.

In *Chemistry*, photography has been of service in registering the belted zones of the spectrum, and making images of these bands, parts of which are invisible to the eye, and by this means not only can we obtain some information regarding the constitution of stars and nebulæ, but also some idea respecting the relative motions of these bodies and our earth.

Military Photography.—The science of warfare has also been aided by the art of photography. Balloons and kites are now constructed capable of carrying a camera with which photographs can be made of the surrounding country, the position of the enemy, strength of their fortifications, etc.

For mapping and surveying this arrangement would also be of great use.

In *Meteorology* photography assists by giving permanent records of the dark nimbus and the bright rolling cumulus clouds. The lightning flash is clearly shown as it really is. Further, it helps the meteorologist by registering for him the rising and falling of the barometer and thermometer.

In *Microscopy* we are able to photograph the disease-bearing generations of *bacteria*, *vibrio* and *schizomycetes*, and to throw these photographs on a screen so that the image of the little flea assumes the proportions of the gigantic elephant.

Indeed, the uses of photography are many. It has been used to send letters from besieged cities to anxious friends and relatives outside. It has served to photograph the action of the torpedo in throwing up the water, and to give truthful records of the field of battle. It helps the clever engineer by multiplying his plans and by giving him evidence of work done above or below the ground, determining the depths of the sea, and the directions of currents. It serves to keep in the hands of justice the image of the villainous murderer, or the avaricious forger. It detects the spurious banknote, and assists the expert in his tests of handwriting. No traveler's equipment is complete nowadays unless it contains a set of photographic apparatus, enabling him to bring back from his travels pictures of the curious things that he has seen, and the picturesque places that he has visited.

These are a few among the many things which photography does for mankind. Every year shows some fresh use for it, and it is difficult to say where it will end, if end it will.

PHOTOGRAPHY IN COLORS.—See **Heliochromy.**

PHOTOGRAVURE.—A very beautiful photo-mechanical printing process, giving soft and most artistic results. The principles of the process were first suggested to a French firm by Woodbury, the inventor of the Woodburytype, and the process was eventually worked by them with great success. There are now several different photogravure processes worked by different firms. The details of these processes are, however, kept a close secret.

The following process is not by any means a difficult one. The first operation is to prepare from the negative a transparency with special carbon tissue for that purpose, developed on a prepared glass plate. Like all other photographic processes a good negative is necessary; it should have plenty of detail, and strong without being hard. From this negative a carbon transparency is made upon glass,† and when quite dry it is placed on the retouching desk and carefully worked up. To do this properly it requires the work of an artist, who can, by touching up the details, make an artistic picture from the photograph. It is an acknowledged fact that the majority of the magnificent photogravures that are sold have required weeks, and in some cases even months, of the artists' retouching work, improving the light and shade.

The next operation is the preparation of the copperplate, which is to form the intaglio block from which the prints are made. The dimensions of the plate should be one or two inches wider each way than the size of the picture to be printed. It should be well polished, and have the edges bevelled slightly. The copperplate is now thoroughly polished, and freed from scratches by dusting over a little very fine emery powder, moistening it with a little mixture of vegetable naphtha and turpentine, and well rubbing with a piece of soft flannel or lint. When it has become bright, the emery powder is removed, and a little whiting, moistened with the turpentine and naphtha mixture, applied. With a clean piece of flannel or lint the plate is given the final polish. All traces of emery or whiting are then carefully removed.

The next process is the laying the etching ground upon the plate. For this purpose we require an apparatus constructed especially for the purpose.

It consists of a box of suitable dimensions, fitted on two pivots and with a handle, enabling it to be revolved. A small opening at the bottom fitted with a door is made in front. In the bot-

* See Photogastroscope. † For instructions see Transparency.

tom of the box a number of nails are driven to rest the plates upon. The method of using this apparatus is as follows: About a pint of equal parts of very finely powdered resin and asphaltum is put into the box, the door closed, and the apparatus revolved very rapidly. The effect of this can be imagined, the resin and asphaltum dust fill the air in the box. A few seconds are allowed for the coarser particles to subside, and the door is then opened and the plate inserted and allowed to remain there for about 15 or 20 minutes. It is then removed and will be found to be covered with very fine asphaltum-resin dust. It must be very carefully handled, as the slightest draught or a heavy breath would displace the dust and spoil the effect. Directly it is removed from the box it is laid upon a heating apparatus with a temperature of about 150° F., where it remains just until the dust is melted sufficiency to adhere to the copper. A very great deal of the subsequent effect depends upon careful manipulation at this point. If insufficiently heated the dust will not melt and adhere to the plate, and if overheated the resin and asphaltum will form a homogeneous layer instead of what is required, *i. e.*, a collection of fine dust particles through the interstices of which the etching fluid can penetrate.

The copperplates prepared in this manner can be preserved for any length of time. It is well, therefore, to prepare a number at a time and store carefully away for future use.

This method of laying the ground is probably the one most generally employed. There are several other methods, however. One is by means of an air brush, a solution of the asphalt and resin being blown on to the plate in the form of a spray.

The following two methods are also given in Wilkinson's work on Photogravure.

The ground is laid by first coating the polished plate with a five per cent. solution of camphor in methylated chloroform and a five per cent. solution of white resin in benzole mixed together. When dry the plate is laid on the heating apparatus until the camphor ceases to smell and the resin begins. It is then cooled and the ground is ready.

The other method is to oil the copperplate with olive oil; then to dust over with flower of sulphur and allow to remain a few hours, when a slight tint will be etched all over the plate, more or less deep in proportion to the time given. These plates must be cleaned with ammonia before the next stage.

Bay salt	2 parts
Ammonium chloride	1 part
Verdigris	1 part

ground into a fine powder, mixed with syrup of honey, also gives a good grain,* and may be used after etching to vary the tint.

We have now the retouched transparency and the prepared copperplate. The transparency is placed in a printing frame, a mask with an opening the size of the picture required laid over it, and a piece of ordinary carbon tissue placed over this, so that the image comes exactly in the center. The frame is then closed up and exposed to the light.

The exposure is regulated by an actinometer (see **Carbon Printing**), as the image is not visible till development.

When sufficiently printed, it is removed from the printing frame and laid in a dish of clean cold water. On immersion in the water the tissue will curl up, and afterwards return to a flat state. It is then removed and squeegeed down on to the prepared copperplate; a few pieces of paper and a heavy weight are then laid over it to press it well down for a few minutes. It is then immersed in warm water about 90° to 100° F. until the paper back becomes loosened and can be readily removed. The temperature of the water is then slightly increased, and the plate laid within until the soluble gelatine is all washed away. The temperature must be raised to about 105°, or if the print is over exposed it will require to be about 110° or 115°. When only the insoluble image on pigmented gelatine remains, the plate is rinsed under a tap and placed in a rack to dry; when quite dry the margin of the copperplate is carefully covered with a black varnish, and the plate laid in the etching solution, which consists of—

Saturated solution of perchloride of iron in methylated spirits	5 ounces
Water	10 ounces

The effect must be very carefully watched. Directly the whole of the protected copperplate beneath the carbon image is discolored by the action of the etching fluid the plate is removed, well washed, and the carbon image wholly removed with a brush dipped in a strong solution of sodium carbonate. The etching process occupies a few minutes only, and therefore requires close attention. The discoloring action of the perchloride of iron is carefully followed first in the shadows, next in the half-tones, and lastly in the high-lights. It should be noted that in the carbon image or "resist," as it is termed, the high lights are opaque, and the shadows transparent. When the action of the etching fluid has reached the light it must be immediately stopped in the manner described.

The action of the fluid is not to deeply etch the plate, but merely to roughen it sufficient to hold the ink when printing. Its strength depends upon the quality of the image. A strongly concentrated solution works slower than a diluted one, so that it is preferable to commence with a moderately strong bath and dilute until the plate is properly etched.

* "Photogravure," by W. T. Wilkinson.

The image and the varnish removed, the next operation is to polish the margin with fine emery cloth, the edges of the picture being protected with a straight edge. The plate is then ready for the printing press.

An ordinary copper-plate press will be required, fitted with two blankets, a thick one next the rollers, and a thin one underneath.

In printing from photogravure plates the ink must be strong in color and in oil. It is applied to the plate with a dabber made of soft cloth or flannel, rolled up about four or five inches long and one inch in diameter. The paper used for printing on should be a good quality of plate-paper. Every sheet must be wetted over with a wet sponge and stacked for a few hours under pressure.

The plate is first cleaned with a mixture of turpentine and naphtha and wiped quite dry. It is then laid on the heating apparatus and warmed until the hand can no longer stand the heat. A little is then put on the dabber, and worked well on the inky slab. The plate is then dabbed all over, and the ink worked well into the engraving with a piece of coarse French muslin warmed, the ink is carefully removed from the margins and whites, and a piece of fine muslin is then warmed, and made into a cushion sufficiently large enough to lay on the palm of the right hand; with this the plate is lightly wiped until ink is apparently left in the depths of the picture only. If the ink is cold it adheres firmly to the plate, hence the necessity of warming the muslin. After properly wiping, the margin of the margin of the plate is cleaned with a piece of rag dipped in turpentine. The plate is then laid in the press, and the print made.

To pull off good prints from a photogravure plate requires a considerable amount of practice. The plate can, if necessary, be further improved by working the high lights with a burnishing tool and strengtheing the shadows with a roulette.

If a number of prints are to be made from one plate it will be necessary to face it with steel. The method given by Wilkinson is the following: The plate is thoroughly cleaned with whiting, moistened with turpentine and naphtha, and polished with a soft cloth. A small portion of the plate is scraped clean, and a piece of copper wire soldered to it. The steeling solution is placed in a wooden cell, the positive and negative poles from a Léclanche battery ending in copper rods the whole length of the cell. The solution is composed of:

Warm water	20 ounces
Ammonium chloride	3 ounces
Iron sulphate and ammonia	4 ounces

When dissolved, filter, and let it stand in the cell twenty-four hours before use. The copperplate is hung upon the rod connected with the negative pole* of the battery, the positive pole being attached to a plate of pure steel about the same size, or a little larger than the copperplate. When the two plates are in position the current is turned on. Three to five minutes suffice to complete the operation of covering the copperplate with a fine thin film of steel. The plate is removed, thoroughly washed and cleaned with whiting and turpentine and naphtha solution. The copper wire is unsoldered and the back scraped flat.

Prints should be dried separately, then slightly damped and laid between sheets of tissue paper, and placed under pressure till dry again.

If a title or name is required to be printed on to the plate, the whole must be coated with a thin film of bitumen varnish. The letters are then made with an etching needle, which must go right through the varnish, and the title written backwards, of course. It is then immersed in the etching solution for a few minutes, the varnish removed, and the plate is ready for the printing press.

There is another process of photogravure, the details of which are kept a profound secret. In this the translation of photographic half-tones into the corresponding grain required for printing is said to be effected by the aid of a substance which crystallizes when exposed to the light, the size of the crystals depending upon the amount of light received. Such a substance exposed under a negative will give a surface the grain of which will exactly correspond with the lights and shades of the picture, and from which an electrotype can be made for printing purposes.

PHOTO-HELIOGRAPH.—An instrument used in astronomical photography (*q.v.*).

PHOTO-LITHOGRAPHY.—It will perhaps be as well, before describing the process of photo-lithography, to give some outline of the theory of ordinary lithography. This was invented by Senefelder, who was the first to discover the remarkable properties of the Solenhofen limestone. It is said that, for want of paper and ink to write to his mother, he casually used the surface of this stone instead of paper, using a mixture of soap, wax, and soot for ink, having the intention of copying on to paper at a convenient opportunity. When about to efface the writing the thought struck him, why not etch the stone with an acid. He tried this, and was delighted with the result he obtained. From this he built up the whole process of lithography.

The action of the acid is to etch away a very thin layer of the unprotected stone, while the writing remains intact, but naturally left a little in relief. In addition to this effect of the acid

* In a Léclanche cell the zinc is the positive and the carbon the negative.

it forms upon the surface of the stone, where attacked, nitrate of calcium, which possesses the property of resisting and refusing the fatty ink upon the surface of the roller.

Lithographic stones are prepared by cutting into slabs and grinding and polishing the surfaces. The chalk with which the drawing is made on the stone is composed of soap, wax, tallow, and shellac, with finest lampblack added for color. These ingredients undergo a change, and form with the stone a very stable chemical compound. The fatty acids (oleic and margaric acid) are set free from the soap and tallow by the nitric acid, and combine in the nascent state with the lime to form oleomargarate of lime. This compound adheres firmly to the stone, and by applying turpentine the image may be apparently completely removed from the stone. It is not, however, for if the ink roller be again applied the very finest details will be found to have remained intact, and make their appearance by the ink adhering to the oleomargarate of lime, and refusing to adhere to the stone, which, by the etching process, has become wet with nitrate of calcium.

This is then the theory of lithography simple. In photo-lithography we substitute a photographic image for the artist's drawing.

Bitumen Process.—The very earliest process was discovered by Niepce even before the discovery of photography itself. This process was based upon the peculiar property possessed by asphalt or bitumen of becoming insoluble in either benzine or turpentine if exposed for some time to the action of light, these agents readily dissolving it if unexposed. The lithographic stone, poured over with a solution of asphalt dissolved in turpentine in the dark-room, is dried and exposed under a reversed negative to the action of sunlight for several days. By means of turpentine or benzine the unexposed parts can then be dissolved away, leaving an asphalt image of the exposed parts, which can be inked in and etched in the ordinary manner. Owing to the perfection attained by the transfer method now generally employed, this process is not much used. The method of obtaining the image in asphalt is, however, generally adopted for heliographic engraving or etching on copper or steel plates.

The special photographic application of this group of coloring matters to be described depends firstly upon the sensitiveness to light of their diazo-derivatives, this sensitiveness being increased in a very remarkably degree by combination with the complex colloids which constitute the textile fabrics. The actual photographic agent is the diazo-primuline, in which form the image is produced, and the development of the image consists in its conversion into any of the coloring matters obtainable by combination with phenols and amines. It will be obvious that the images produced will be positives.

Direct Photo-lithography.—The bitumen process may be said to be a direct process. Another is the following:

The polished stone is spread over with a solution of gum-arabic and potassium dichromate. It is then dried in the dark, and exposed under the negative. After this the stone is well washed and rolled in with ink. There are one or two other methods of directly printing the image upon the stone; none, however, have come into practical use, or superseded the photo transferred from paper.

Transfer Method of Photo-lithography.—In this a sheet of paper is coated with gum, albumen, or gelatine containing potassium or ammonia dichromate. It is then exposed to light under a negative, and after exposure is uniformly coated with printers' ink. This inked paper is then immersed in warm water, and the surface gently rubbed with a soft brush, which removes the ink from the parts not acted upon by the light. Where the light has rendered the colloid substance insoluble, it retains its hold of the ink The image in printers' ink is now called a photo-lithographic transfer.

Success in photo-lithography depends to a considerable degree upon the quality of the negative and of the paper used for making the transfer.

The old wet-collodion process is the most suitable for the production of the negative, as great density and contrast are essential. To produce a perfect negative for this purpose requires a great deal of practice. Not only must every line in the copy be faithfully reproduced in the negative, as clear glass and the white ground have considerable opacity, but the utmost sharpness possible of every dot and line is also necessary. If gelatine plates be used they should be very thickly coated. Professor Burton recommends the following emulsion for dry plates, especially for photo-mechanical line negatives.

I.

Ammonium bromide	1,000 grains
Potassium iodide	80 grains
Gelatine	320 ounces
Water	40 ounces

II.

Silver nitrate in crystals	1,600 grains

III.

Hard gelatine	1,200 grains

No. 1 is raised to a temperature of about 120 deg. F., and No. 2 added (dry), stirring continuously. No. 3 is then added, also in a dry state. When the whole is melted the emulsion is precipitated with alcohol and washed, or it may be allowed to set and then washed.

The paper used in making the transfer should be smooth, well sized and with plenty of body. In this country that known as bank post paper is generally employed. Professor Husnik's process for preparing it is as follows* :—One part of finest gelatine is swelled and then dissolved in 24 parts of water, a solution of chrome alum, 1 in 100 of water, is then added, and the solution while still warm is poured into a large zinc dish heated to 34 deg. R. by means of a petroleum or spirit lamp. The scum is first removed from the surface of the solution, and the paper floated, one sheet at a time, and hung up to dry. The sheet is floated on the gelatine solution a second time, and again suspended, this time by the diagonally opposite corner to the one by which it was previously hung. A solution of white of egg one part, water two parts, is next prepared, and the paper floated on it. After again subjecting to the drying process it is ready for sen sitizing. This is done with a bath of—

Water	14 parts
Potassium dichromate	1 part
Methylated spirit	4 parts

with sufficient ammonia to turn the reddish solution to a bright yellow one. After floating it is dried by hanging up in the dark.

Another method of preparing a gelatine transfer paper employed in the Military Institute in Vienna is thus described.† A sheet of well sized paper is laid in a dish of water to soak, and when quite limp it is drained and place on a glass plate made perfectly level All air-bubbles and superfluous moisture are removed by means of blotting paper and a squeegee. The edges of the paper are then turned up about 2 c.m. all round, and a warm solution of gelatine (1 in 30) poured on. In a few minutes the gelatine will have become quite set, and the sheets are laid on wire netting to dry, the operation requiring usually about two days. A day previous to using, the gelatine paper is sensitized by immersing in a cold bath of potassium dichromate and water (1 in 15). On removing from this bath it is allowed to drain, and the gelatine side placed on a glass plate. The back is then dried with blotting paper and all air-bubbles removed. These operations and the drying afterwards must be done in a non-actinic light. To prevent the sheets when dry from adhering either partly or wholly to the plate, it is advisable to wax the glass or apply to its surface a weak solution of oxgall.‡

In the Calcutta Government Photograph Office a new method of preparing the photo-lithographic transfer process has been introduced, arrowroot being used instead of gelatine. Bank post paper is coated in the usual way with two coatings of the following mixtures :—

Arrowroot	140 parts
Potassium dichromate	70 parts
Water	3,500 parts

After exposure to light the prints are coated with transfer ink in the press as usual, the transfer ink used being composed of—

Hard re-transfer ink (plate to stone)	100 parts
Lithographic chalk ink	100 parts
Palm oil	7 parts

After inking, the prints are washed off with hot water, hotter than is required for gelatine transfers.

When transfer paper is not prepared in large quantities, ordinary commercial gelatine paper, or the double transfer paper used in the carbon process, may be used if prepared by floating on a bath of albumen (beaten to a froth and allowed to stand) 50 parts, water 50 parts, and potassium or ammonia dichromate 7 parts. On this the paper is floated for a few (about five) minutes. The solution will not keep.

All sensitized transfer paper should be used as soon after sensitizing as possible. As soon as dry it is exposed under the negative for a few minutes in sunlight when possible. The image appears of a brownish-gray color on a yellow ground, and may be examined by a non-actinic light. When all the detail is visible it is removed from the frame.

The room in which the operations of sensitizing, drying, inking up, etc., are carried on, must be lighted by windows covered with golden fabric or by gas or lamplight.

After exposure, the transfer is then inked up. A little photo-transfer ink is mixed with turpentine, and the glue roller charged with it until the whole sheet is uniformly covered with ink. It is then placed in a dish of cold water, and allowed to soak for some minutes (about a quarter of an hour will usually suffice). It is then laid on a smooth slab, and carefully rubbed with a pad of wet lint until the whole of the loose ink is washed away. The photo-litho transfer may also be put down in the same manner on a zinc plate, and then treated in the same manner

* See "Collotype and Photo-lithography," by D. J. Schnauss, translated by E. C. Middleton. † "Photographisches Correspondenz.

‡ A more reliable method of imparting to the surface of the paper a high gloss is to squeegee it down upon a ferrotype plate, the surface of which requires no preparation, and the risk of sticking is *nil*.—E. C. Middleton.

as the stone. The effect of this is that the printer's ink becomes removed from all those parts unexposed to the action of the light, and an image in fatty ink is obtained on the gelatinized paper. From this the superfluous moisture is removed with blotting paper, and the print, ink face downwards, is laid on a clean and slightly warmed lithographic stone. Both are then passed through the press, and the transfer adheres firmly to the stone, but by moistening the paper with a sponge it becomes easily removable. When stripped from it the fatty ink will adhere to the surface of the stone, leaving a perfect reversed image on it. The stone is then gummed and etched in the ordinary manner employed in the process of lithography.

PHOTO-LITHO TRANSFERS.—See **Photo-lithography.**

PHOTO-MECHANICAL PROCESSES.—The term photo-mechanical is applied to all processes in which the action of light upon chemical substances becomes the means of preparing printing surfaces from which many impressions can be made without any further assistance of light.

The first photo-mechanical process known was that invented by Nicephore Niépce about 1827, when he discovered the peculiar sensitiveness of asphaltum to light. He coated metallic plates with a solution of this substance, and exposed them in the camera to the image. Those parts acted upon by the light became insoluble, while the remaining portions were dissolved away with oil of lavender. By this means a reversed picture of bitumen was obtained on the metal plate. By next applying an etching acid the parts of the metal unprotected by the bitumen image were eaten into, and after clearing away the image a printing plate was obtained.

Many photo-mechanical processes are based upon this property of asphaltum, but many more upon the sensibility of dichromatized gelatine, albumen, and gum arabic, and their peculiar properties. These substances are used to produce the design, either flat for etching or direct printing, or in relief for moulding electrotypes, stereotypes, etc.

For some time the chief difficulty that was encountered was in the correct rendering of the half tones. This was eventually overcome by breaking up the image into lines, dots, or stipples.

Photo-mechanical printing processes may be divided under two different heads, *i.e.*, those in which the image is moulded in pigmented gelatine, and those in which the picture is printed with the ordinary fatty printing inks. To the first class belong the Woodburytype and Stannotype processes.

The *Woodburytype* was the invention of W. B. Woodbury. In this a sheet of bichromatized gelatine is first exposed under the negative, and afterwards washed in warm water, which removes the soluble parts, leaving the image in relief. When the gelatine relief is dry it is exceedingly hard, and is pressed by means of hydraulic pressure into a sheet of lead. By this means an intaglio mould is formed. This is placed in a specially constructed press, having a heavy and perfectly true lid. A little warm gelatine solution, containing any desired pigment, is poured on to the intaglio mould, a piece of prepared paper laid on top of it, and the heavy lid brought down. This squeezes the excess of colored gelatine, allowing only that to remain which lies in the mould. This sets, and at the same time adheres to the paper support, which, when removed, has attached to it the gelatinous image. This is dried and hardened with chrome alum. If glass be used instead of the paper very beautiful transparencies can be made.

The *Stannotype* process is a modification of the Woodburytype by the same inventor. In this tinfoil, properly backed by electrotyping or by other means, is substituted for the lead plate, thus doing away with the necessity of employing expensive machinery.

A very large number of processes come under the second classification, *i. e.*, those which are printed in ordinary printer's ink. These, however, may be again divided into the following: (1) Processes in which the image is printed from a gelatine surface. (2) Processes in which the picture is printed from stone. (3) Processes in which the image is printed from a metallic surface in relief. And (4) processes in which the image is printed from an intaglio metal plate.

Among the processes in which the picture is printed from a gelatine surface the chief are: Collotype or Albertype, Artotype, Chromo-collotype, Indotint, Leimtypie, and Heliotype.

In the *Collotype* process a sheet of thick plate-glass is first coated with a film of albumen and gelatine, to which a dichromate has been added. This is then laid on a piece of black cloth exposed to light, washed and dried, and the plate is then coated with dichromatized gelatine, exposed under a reversed negative, soaked in water to remove all soluble chromium salt, hardened with alum, and finally dried. By this means a scarcely visible image in gelatine is the result, those parts which have been exposed to the light being insoluble and repellant for water, the remaining parts retaining their absorbing properties. The plate is fastened to the bed of an ordinary lithographic press, the printing being very similar. A wet sponge is used to moisten the absorbing parts of the gelatine (the whites in the picture), and an ink roller inks the image part. A sheet of paper is laid over it, and, after pressure is applied, the ink is transferred to the paper. Prints may also be made upon cotton and silk fabrics.

The *Artotype* process is very similar to the Collotype, a slight improvement being made by Obernetter. A mixture of soluble glass and albumen was used for the foundation film, thus avoiding the necessity of first exposing to the light. In all other respects the process is similar to the Collotype.

Chromo-collotypes are produced with a number of Collotype plates, using differently colored inks. The negative to be reproduced is first blocked with opaque varnish in all parts except those required to be reproduced in a certain color. From this a collotype plate is made to be used with that colored ink. The varnish is then removed and the negative blocked for another color, and so on. In printing, the paper is passed through with the different plates until all the colors have been printed on it, forming a complete many-colored image. Instead of blocking out the negatives they are sometimes made by photographing the object through different colored screens, which have the effect of shutting off or absorbing some colors and allowing others to pass through undisturbed to the sensitive photographic film.

The *Indotint* process was invented by Roche, of New York. A copper plate is used, roughened by exposure to the sand-blast, causing the sensitive film to firmly adhere. The film is also roughened by the addition of alcohol to the dichromatized gelatine. After exposure the unaltered dichromate is removed by washing, and the plate dried.

Leimtype.—This process was invented by Husnik, of Prague. He takes a thick plate of chromatized gelatine and exposes it under a negative. This is then attached to gutta-percha, zinc, or wood as a foundation. The image is next developed with a solvent such as a saturated solution of alkaline dichromate. This has the double effect of dissolving the unexposed parts, and deepening and strengthening the relief. The high lights are protected, and the relief again exposed to the light, after which it is again developed to deepen the whites and further strengthen the image. Plates thus produced can be used in the ordinary printing machine with the letterpress. Electrotypes can also be made from these plates when a very large number of copies is required.

The *Heliotypie* process is closely allied to the Collotype. The most important difference is that the gelatine film containing the image is hardened with chromic alum, and detached from its support. It thus forms a thin sheet or "skin," as it is termed, which can be laid on to a zinc plate, or attached to the cylinder of a printing machine. Further, it can be easily preserved for printing from on future occasions when desired.

In our next class, *i.e.*, those processes in which the image is printed from stone, we have to mention the following:—Photo-lithography, ink-photo process, and the photo-caustic process.

In *Photo-lithography* an image is either made upon the stone direct, or first upon specially prepared paper and afterwards transferred to the stone. The transfer process is the one most general. A full description of the process will be fonnd under **Photo-lithography.**

The *Ink-photo* process is a method of photo-lithography in half-tone. The process was invented by Sprague, of London, the details being kept a secret.

Photo-caustic is the name given to photo-lithographic images in half-tones by means of a Meisenbach veiled negative.

With regard to those processes of typographic or block printing where the image is printed from a metallic surface in relief, they may be conveniently divided into two divisions, *i e.*, the swelled gelatine processes and photo-etchings. Under the first we have the photo-electrotype, photo-engraving, and Mosstype processes. There are a very large number of photo-electrotype processes, differing in minor details. The process may be briefly described as follows:—A sheet of chromatized gelatine is exposed under a negative. Parts are thus rendered insoluble and incapable of absorbing water, the remaining portions, protected by the image of the negative, being soluble and capable of absorbing cold water. After exposure the gelatine is immersed in cold water, when the absorbing parts swell up, or else the soluble parts are removed with warm water, acetic acid, or other solvent. The next process is the making of moulds in wax, or plates from the gelatine image; and from these copper blocks can easily be made for typographic printing by the electrotype process. If half-tones are to be represented the negative must be broken up into lines, dots, or stipple.

The term *Photo-engraving* is applied to processes of making metal relief blocks. The manipulation is somewhat similar to that just described. A full description will be found under **Photo-engraving.**

The *Mosstype* process is a photo-engraving process, differing slightly in detail from that described. This is first made in a composition of asphaltum, sulphuretted resin, and caoutchouc, and from these a second mould of plaster is made, from which a casting is made in type metal to form the printing block.

Among the photo-etching processes are photo-zincography, zincotype, typogravure, and chromo-typogravure.

The term *Photo-zincography* is one that is applied to many differently detailed processes in which designs in adhesive transfer ink are transferred to zinc plates in the same manner as transferred to stone in photo-lithography. An etching agent is then applied which eats into the zinc at the unprotected parts, producing the design on the zinc in low relief. See **Photo-zincography.**

In *Zincotypes* the zinc is first coated with bitumen or bichromated gelatine or albumen, and exposed under the negative. The image is then developed. If the bitumen process is employed, oil of turpentine is used as the solvent, but in the other method the albumen is first

coated with printers' ink, and then developed by gently rubbing in cold water with a tuft of cotton wool. The unprotected parts of the zinc are then washed away.

For producing these blocks in half-tones a variety of methods are employed of breaking up the negative image.

The *Typogravure* process is a method of obtaining half-tone pictures from copper relief plates, worked by Messrs. Boussod, Valadon & Co., at Asniéres, near Paris. The details of the process have never been published. Chromo-typogravures are produced by the same means, a number of different plates being used with different colored inks to form the many-colored image.

In the last class, *i.e.*, those processes in which the picture is printed from an intaglio copper-plate, we have photogravure, Goupil-gravure, and photo-aquatint. The idea of producing copper intaglio plates by means of photography was first worked out by Niepce; many others followed. About 1870 or '71 Woodbury suggested to Goupil & Co. a method of photogravure which was taken up and worked by that firm with great success. A gelatine relief was made in the same manner as for the Woodbury-type process, except that a fine gritty powder was added to the gelatine to give the necessary grain. From this relief a mould and an electrotype are made. Other processes are described under **Photogravure.**

The *Goupil-gravure* process is a method of making *facsimiles* of water-color drawings. The plate is carefully inked in by hand with the different colored printing inks, and the picture printed by one impression. The plate is cleaned and again inked for the next picture. The method of printing is, of course, very costly, as skilled artists have to be employed for coloring the plates. The results, however, are truly fine, and in some cases hardly distinguishable from the original water-color drawing.

By the *Photo-aquatint* process images are made from intaglio copperplates in a similar manner to photogravure. It is chiefly used for the reproduction of portraits taken direct from life.

This sketch of the different photo-mechanical printing processes is necessarily very incomplete. Correct information regarding these is very difficult to obtain; all firms working the processes naturally keep the details as close a secret as possible. More detailed descriptions of the most important are given in their respective places.

PHOTOMETER.—A contrivance for calculating the intensity of light. See **Actinometer.**

PHOTOMETRY.—The process of measuring the relative amount or intensity of light emitted by different sources.

PHOTO-MEZZOTYPE.—A photo-mechanical printing process similar to Collotype.

PHOTO-MICROGRAPHY.—The science of photographing microscopic objects. Considerable strides have been made in this within the last few years, and the aid given to the microscopists is incalculable. Hitherto skilled artists were required to draw what was visible to the eye. This was in most cases a difficult matter, as the structure of nature's works is so intricate and delicate that magnified objects could rarely be reproduced by hand with fidelity. By means of photography, however, we get faithful images of the objects in a few seconds.

In practice we require three essential things. These are: A camera, a microscope, and a lamp. Many arrangements have been devised for photographing microscopic objects. The simplest is a small camera made to fit on to the upper end of an ordinary microscope in place of the eye-piece. Fig. 333 illustrates a more perfect form of photo-micrographic camera.

The microscope used should be a firmly-built solid monocular with a fine adjustment. The light used must be accurately centered, otherwise one side of the object will be dark and fuzzy.

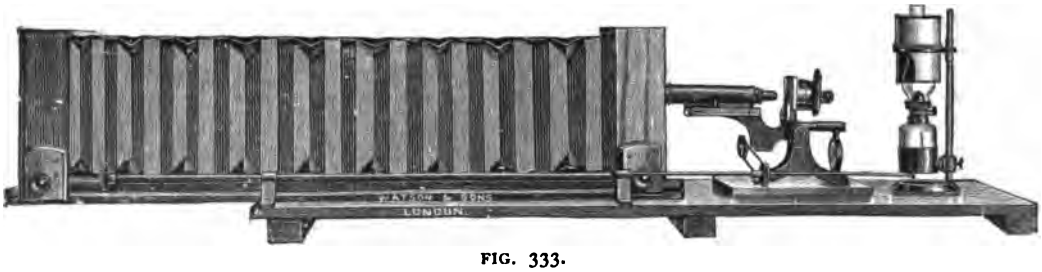


FIG. 333.

The tube of the microscope should be coated with a dead-black varnish or lined with dull black paper.

The light can be an ordinary microscope lamp burning best paraffin oil containing a little camphor dissolved in it to increase the brilliancy of the illumination.

Another indispensible adjunct is a substage condenser fitted with a revolving series of stops.

Before attempting to focus, the lamp should be allowed to burn for ten minutes, so that the whole instrument may become thoroughly warmed throughout, otherwise the expansion will alter the focus very considerably. Great care must be taken in focusing the object as sharply as possible. Charters White recommends the removal of the ordinary glass focusing screen, replacing it by a plain glass, having some fine lines drawn across it with a writing diamond, these lines being placed next the objective. The focusing glass is then set until these lines are sharply defined. These lines will closely approximate to the plane of the emulsion on the sensitive plate, therefore if the details of the object are in focus with the lines on the focusing screen, the probability will be in favor of a sharp image on the negative.

With regard to the exposure. This varies in proportion to the magnifying power of the objective used, and the color of the object itself. The times in the following table (by Walmsley) may be considered as approximate, but variable with the color and general character of the object to be photographed.

1½ inch objective	3·45 seconds
⅔ inch objective	7·90 seconds
$\frac{1}{10}$ inch objective	½·3 seconds
⅔ inch objective	2·7 seconds
$\frac{1}{10}$ inch objective	4·10 seconds

Experience only will teach the correct exposure, however.

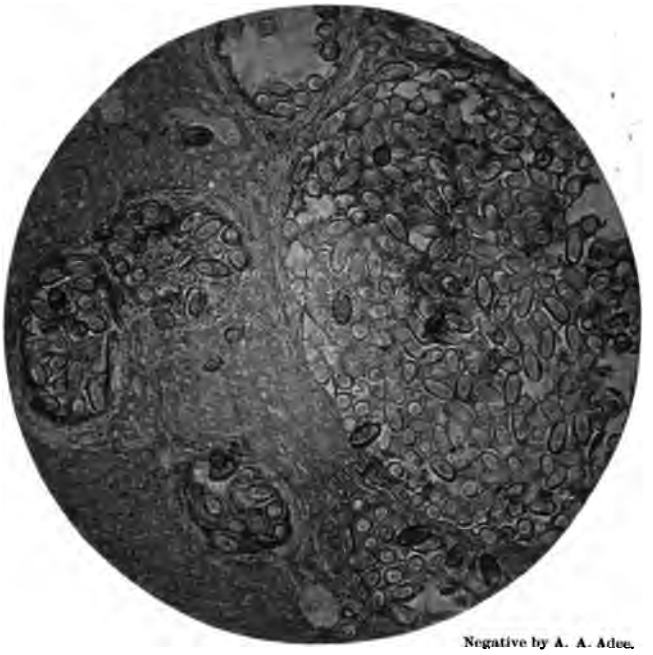
Mr. A. A. Adee, writing in the "American Annual" for 1895, gives some valuable hints to those desirous of studying this fascinating branch of our art. He says: "While the attainment of the highest results in microscopic photography demands signal proficiency and an outlay running far into the hundreds, any possessor of a fairly good compound microscope and a small camera can produce pictures at once interesting and meritorious. It is a mistake to suppose that an elaborate stand with modern apochromatic objectives and illumination by heliostat or calcium light is requisite, except for the most advanced bacteriological and diatomic work. Indeed, it would be a positive drawback to the mere amusement seeker to have so expensive an outfit, for he must needs undergo a year or two of professional tuition or wasted experiment before reaching critical success.

"I long shared the general belief and postponed any essays in this tempting direction until I could get an eight hundred dollar apparatus, thereby missing several winters of singularly interesting pastime. Having a good Nachet stand with mechanical stage and a well selected set of objectives, and also a discarded 4 x 5 camera, it at last occurred to me to put them together and try conclusions therewith. A stout base-board, four feet long and six inches wide, slotted along the middle and set on turned four-inch legs, gave a good beginning. To this five suitable blocks of wood were fitted, each having a screw-pin passing through the basal slot and fastening by a thumb-nut. To the rearmost block the camera was pivoted, a paste-board funnel with black-velvet lining being attached to the front, so as to allow some two feet draw. To the next block the microscope was firmly clamped, the eye-piece being, of course, removed, and the open tube being joined to the little end of the funnel by a light-tight sleeve of velvet. The third bore a big bull's-eye condenser, and the fourth a heat and light filter. The heat-filter gave a world of trouble, but a six-inch ring cut out of half-inch all-rubber steam-packing, with plates of stout glass generously cemented to each side by means of a paste of red lead and gold size, supplied a water-tight cell, a hole being bored in the rubber wall to admit of filling it. A flat-sided pocket flask of clear glass, holding half a pint. was afterwards found to do nearly as well. It should be filled with a strong (40 per cent.) solution of copper *nitrate*, to which a grain of chromic acid is added, giving a practically monochromatic blue-green light that does not call for the long lamp-light exposure needed by the yellower liquid usually employed for modifying direct sunlight. One can't get along without a heat-absorbing cell, even if it only contains pure water; if it be omitted the warmth of the condensed lamp rays will often melt and ruin a balsam-mounted slide, or, at least, cause it to run, thereby shifting the object and yielding a panoramic effect, which is disheartening in a negative. On the last block came the lamp, a common, low-bodied kerosene hand-lamp, with a two-inch flat wick and a roomy chimney of the Rochester pattern. It was set with the edge of the flame toward the microscope, and the inside of the chimney away from the flame, was coated with a round patch of smoke from a wax gas taper, so as to avoid reflection. A reflector behind the source of light ought not to be used, for the beam is thereby so broken up as to throw a distorted pencil, and what is gained in light is lost in definition. Care was taken to so adjust the thickness of each supporting block that the optical axis of the whole system ran truly from the flame, through the tube of the microscope, to the focusing screen. To the center of the latter, on the ground side, a one-inch cover circle was cemented with balsam in order to focus the image on the transparent spot by means of a set lens.

"Proper illumination is the most difficult thing to obtain, and withal the most indipensable. An unmixed ray from the edge of the flame, passing perpendicularly through the filter-cell and evenly converged on the object by a good bull's eye with the flat side turned toward the stage of

the microscope, will give a large, level field of well-focused definition. A broken ray, full of cross refractions and unevenly condensed, shows only a small patch of moderate sharpness, and even in that, spectral diffraction borders are apt to appear. These ghosts will sometimes spoil an otherwise perfect negative when the flame wavers in a draught. A 'critically' disposed light is surprisingly different in its effects from one 'uncritically' adjusted. The minute hairs on a house-fly's wing afford a simple test—under a quarter-inch objective, if badly lighted, they show double points diverging from their base.

"The fine adjustment of the microscope must be attached to some adequate contrivance so as to be readily operated while the observer stands before the ground-glass screen. A side-rod, with milled head at the hither end and a pulley wheel at the other, from which a thread band passes over the milled head of the micrometers crew, is pretty, but bothersome to apply, and not as sensitive to manipulate when the higher powers are employed as is the more primitive device of a stout thread with a weight at each extremity. This is waxed in the middle where it runs over the micrometer head, and thence passes through guide rings at the sides of the general base-board to the operator's hands, where the weights hang right and left, convenient to the slightest touch.

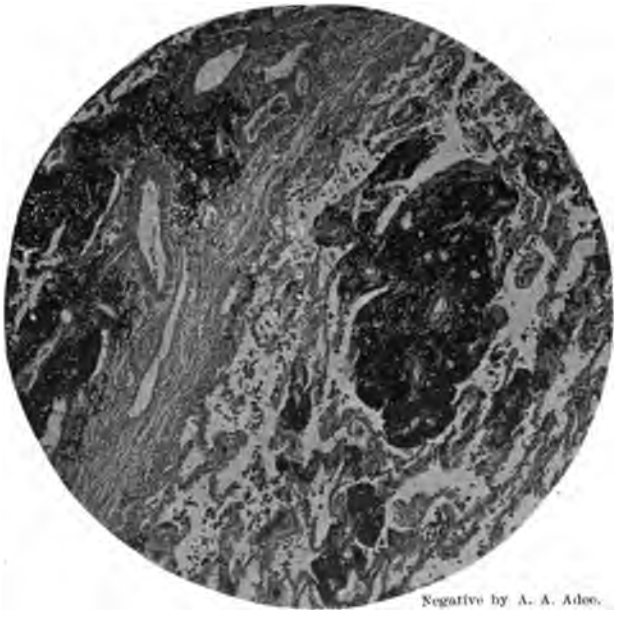


Negative by A. A. Adee.

FIG. 334.—LIVER OF MOUSE, EGGS OF TRICOCEPHALLS. × 100. REICHERT, 8MM.

"This inexpensive apparatus permits of really excellent photographs of thin sections being taken with objectives of from two inches to one-third inch focus. The resultant magnification depends, obviously, on the distance of the screen from the objective. I find thirty inches a favorable length, as it gives a circle of nearly four inches. If a greater distance be essayed, the light will be correspondingly diminished and longer exposures required, while the gain in amplification is balanced by some loss of sharpness.

"For the higher powers, one quarter to one-eighth inch, a good substage condenser should be used on the microscope itself, and the bull's eye discarded. The common non-achromatic Abbe condenser works fairly well, especially if the angle of the illuminant cone be diminished by removing the smaller top-lens of the combination; but for 'critical' work an achromatic Abbe must be used. With its employment, however, as with marriage according to the old rhyme, one's trouble begins, for it will not do its best unless the pencil of light impinging on its lower face be practically parallel. How to get a straight ray of strong lamp-light is a problem which the makers have not yet volunteered to solve satisfactorily, but it should not be a hard one. Sun-light and a calcium burner, both of which throw parallel rays, being out of the question for me, I have taken a powerful projection lantern and set it as near to the microscope as the intervening heat-filter will permit. As the beam from its projection-lens is a divergent cone, I necessarily lose the greater part of the emitted light, but that which follows the axial centre (no bull's eye being used) proves sufficient for my needs, and the achromatic Abbe condenser does the rest. What I want is a substitute lantern-objective which



Negative by A. A. Adee.

FIG. 335.—ANTHRACOSIS OF LUNG. × 40. BAUSCH & LOMB, ¾-INCH, SERIES II.

will collect all the light from the four and-a-half-inch condenser and project it in a parallel ray about an inch in diameter upon the base of the Abbe.

"Equally with correct illumination, a good objective is essential to creditable work. One of the very best I have is a Bausch & Lomb half-inch with an iris diaphragm set in its tube between the two combinations. Another excellent glass is a Reichert 8-millimeter 'half apochromat,' which shows a larger and flatter field than the full apochromats, giving at 31 inches sharp four-inch circles with a magnification of 100 diameters. There is no occasion for the mere amateur to spend a small fortune on the high-priced apochromats, since almost any first-class achromat of reputable American or English make will do the business as well, even though not especially corrected for photography. Besides being, from the peculiarities of construction, liable to mishap or deterioration, the apochromat field is purposely smaller and less flat, needing compensation by a specially computed eye-piece; and they work slower. Having an excessive numerical aperture, their working distance is narrow and with a conjugate focus of 30 inches to the screen the frontal focus is inversely lessened, so that only the thinnest covers can be made use of with the highest powers. They do their best, and very good it is too, with the aid of expressly constructed 'projection oculars, which flatten the field besides lengthening the working-distance—but this entails such diminution of light as to make accurate focusing difficult by the comparatively feeble rays of a lamp.

Negative by A. A. Adee.

FIG. 336.—LANCES OF BLOWFLY. × 14. HARTNACK, 2 INCHES.

"Assuming that the power of the objective, the strength of the illumination and the angle of the beam converged on the object are in perfect correlation, the management of the substage diaphragm becomes important. If too widely open the image on the screen lacks contrast and it is hard to get a satisfactory focus. By gradually closing the diaphragm, which ought to be of the iris pattern, a point is reached affording marked contrast. To get the right focus it does not suffice to see the object generally well defined — its color becomes a potent aid to the average achromat in order that it may exert its best actinic effect upon the sensitive plate. Remembering that the residual secondary spectrum is usually a palish green in most modern objectives, some delicate trans: parent detail of the object should be chosen, such as a fine bristle or beaded marking, and the micrometer adjustment be manipulated until a tinge is seen on the border line between green and rose. After this actinic focus is secured, I find it does good to still further slightly reduce the aperture of the diaphragm if the light be strong."

Negative by Dr. H. J. Ditmers, 1893.

FIG. 337.—AMPHIPLEURA PELLUCIDA. × 1240. QUEEN, $\frac{1}{18}$TH OIL-IMMERSION.

"In photographing the interesting details of insects and vegetabe anatomy, three objectives are advisable, one of oen and-a-half or two inches focus, one of three-quarters, and a third of one-quarter. Being used without an eye-piece, preference may be given to objected corrected for the American or English tube length rather than the short continental standard, for the lens is less strained when its conjugate focus is stretched to 30 inches. To these three may be added a good one-fifth or one-sixth if an

achromatic substage condenser is to be used therewith. It is best to leave the higher immersion powers to the experts with their heliostats, lime-lights or 2,000-candle arcs at command, inasmuch as kerosene falls short of its duty in the premises, and even if a satisfactory focus can be obtained an hour's exposure is wearisome.

Subjects for successful photographing should be thin, level, and not too dark in color. Very thin sections are the best of all, but such delicate objects as the foot of a small spider, the feathery paddles of the *notonecta*—those tiny beetle-like creatures that affect stagnant pool sand have a habit of swimming upside down—the mouth parts of a mosquito, or the scales of a moth come up nicely. In photo-micrography there is practically no "depth of focus," so that thinness and planeness are imperative. For my part I have taken a fancy to pathological horrors, and the Army Medical Museum has furnished me with many enticing sections of cancers, tumors and similar degenerated tissues. The editor of the "Annual" kindly reproduced a few of my pictures to illustrate a paper. One shows the liver of a mouse, invaded by a singular parasite, the *tricocephalus*, which lays a multitude of eggs in the hepatic substance. Another gives an idea of the curious pulmonary complaint, anthracosis, which attacks miners when their lungs become choked with the fine anthracite dust. A kindred disease is found among the dry grinders of Sheffield. For these two excellent preparations I am indebted to my good friend Dr. W. M. Gray. The view of the lances of the common blow-fly illustrates how critical lighting brings out the slender hairs.

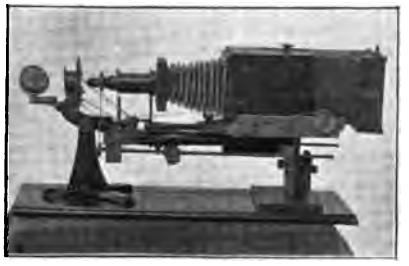


FIG. 338.

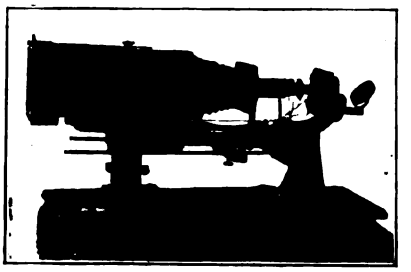


FIG. 339.

I have dwelt so strongly on the imperativeness of securing this "critical" illumination if good results are aimed at, that it may be fitting to close this already too long paper with a comparison of the photo-micrography of a quarter of a century ago with that of our day,* taking that extremely difficult diatom, *Amphipleura pellucida*, the markings of which are but 1.100 thousandth of an inch apart, and so faint as only to be revealed by the most powerful objectives under the best conditions of oblique illuminations. The late Dr. Woodward was, I believe, the first observer to photograph, in 1871, this exasperating test object which so few microscopists have really *seen*. Faulty lighting, apparently, has crowded the field with diffraction spectra. That these were not due to imperfection of the Powell & Lealand $\frac{1}{50}$th water immersion objective he used is inferable from the clearness of the lines on the frustule proper. By the side of this old print is one taken last year by Dr. H. J. Ditmers, with a Queen $\frac{1}{75}$th oil immersion lens, in which the vexatious ghosts are wholly exorcised. The striking difference seems mainly due to the critical improvement in the achromatic condenser and in the more accurate regulation of the light rays.

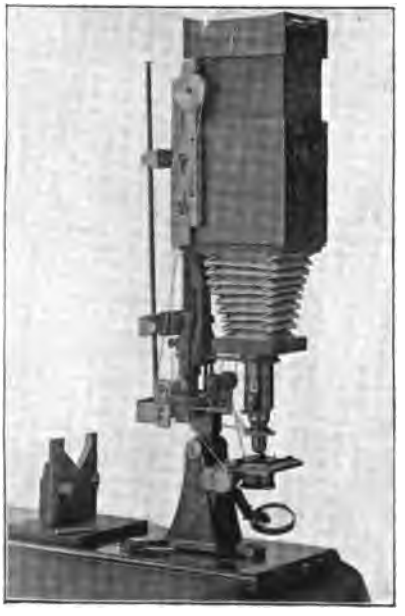


FIG 340.

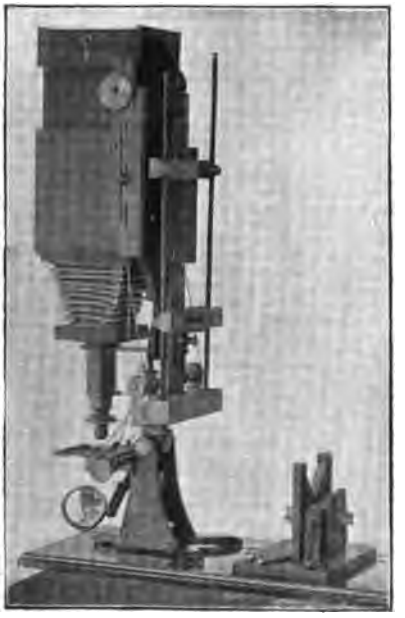


FIG. 341.

The fascinating region of micrography deserves to be oftener explored by the amateur, and especially by those who, like myself, do not have much chance to work by day-light.

Dr. O. G. Mason recently gave in the American Annual of Photography an interesting description of his apparatus, he says:

Any person accustomed to manipulation with the compound microscope, even in some

* This comparison will be found in the *American Annual of Photography for* 1895.

of its simpler forms, may—in these days of dry plates—by the expenditure of a few dollars, or—if handy, with tools, a little time—make such additions to his microscope as will enable him to do much valuable work. If he is a microscopist without any knowledge of the manipulation and chemistry of photography, he yet has some of the most important elements of success, namely, the ability to properly light and focus his subject. The necessary caution in handling and timing exposure to light in the instrument is matter soon learned by experience, and the chemical work of developing and printing may be intrusted to some photographer who will use care in *his* part of the work. The first attempts of the writer in this field of investigation were made with apparatus added to his microscope and at a cost of about six dollars. It consisted of telescoping box of wood and a holder for plates 3¼ x 2¾ (the old $\frac{1}{8}$th size). The ocular end of the microscope body was closely fitted through the front end of this box, which rested on a proper support in the horizontal position, and offered very good facilities for coarse adjustment, while the fine adjustment screw was within reach of the extended arm when seated at the plate holder end of the instrument. Of course, under these conditions the amplification was not great, especially with low power objectives; yet it was quite enough to make the work interesting, and would well answer for lantern slides, which is generally the ultimate use to which such photographic plates are put. As the work by such simple methods increases desire for deeper insight into the mysterious world of wonder which it reveals, more elaborate methods are devised for economizing time and reaching more perfect results. Such has been the prompting influence which led to the construction of the instrument here figured and described.

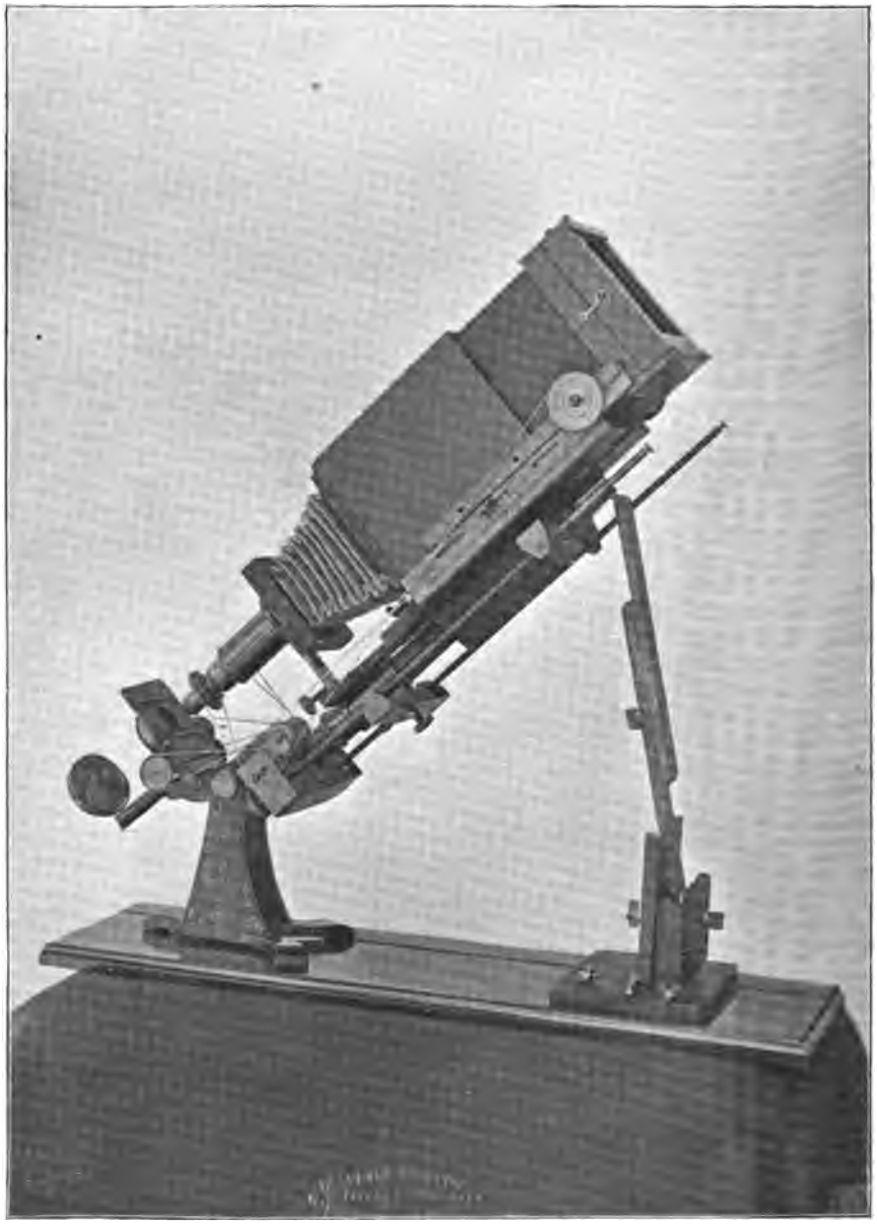


FIG. 342.

In using the microscope with the ordinary length of body or tube—some ten or twelve inches—the field or size of picture obtainable is often restricted by the marginal rays striking the inside of the ocular end of the tube from which they are reflected, and produce a confused image or foggy picture. To obviate such defect the body of the microscope is made short, and is held in position by a firm arm of brass projecting from the metal sleeve, sliding on the square rod which carries the photographic parts of the instrument. This sleeve

is kept in position by a set screw most plainly seen in Fig. 341. The back end of this sleeve is also fastened by a set-screw, one of the bars carrying the bearings for the adjusting rods hereafter mentioned. The back bearing for these rods is attached to the wood sleeve which carries the camera part of the device. This is held in position by a winged thumb-nut seen in Fig. 338 and 339, which clamps it to a sliding tongue held to the arm carrying optical or barrel part by hinged and hooked clamp seen in Figs. 340 and 341. The approximate focus is obtained by the telescoping box, which is held in position by a thumb-nut clasping a slotted tongue of brass on top of the box, as seen in Figs. 338, 339, and 340. On the back end of the sliding box are hooked plate holder carriers, extensions, or such other appliances as may be required. To the side of the bed carrying the camera box are secured adjustable slats, which provide means for tightening the belts passing over the larger pulleys which they carry, as seen in Figs. 338 and 339. These long belts put in action the spool pulleys which carry shorter belts for moving the mechanical stage across, or up and down the field of the objective, as shown in all the figures. The rod on the right hand side of the instrument carries a pulley for making the fine adjustment, as best shown in Fig. 341.

The rod on the left carries a pulley for the band passing over a grooved ring attached to collar of the objective for cover-glass adjustment. The iron stand carrying the stage, substage, mirror, etc., is attached to the bar supporting camera-box and other parts by a strong screw worked by a short lever, as seen in Fig. 338. The head of this lever-screw serves another important purpose in preventing injury of objective or cover-glass by meeting the head of a long screw passing through the vertical arm which supports the optical parts as shown in Fig. 338. The use of adjustable support for back of camera-box is so plainly shown in the figures as to require no written description. In conclusion, a few words regarding some of the peculiar advantages of this instrument may not here be out of place. First, the mechanical and optical parts are so constructed that any slight vibration will not throw them out of adjustment, as all are firmly attached to one center, which admits of the whole being easily put in horizontal, vertical or angular position, as the work in hand may require. All parts are adjustable for wear, atmospheric changes, and the various classes of work. The operator, seated at the back of the camera, can manipulate the whole instrument with ease and certainty, even to the adjustment for cover-glass, and searching the field for any particular object, or selecting the most suitable for his purpose. The whole apparatus is light and compact. Size of plates used, $3\frac{1}{4} \times 4\frac{1}{4}$. The large Bellevue instrument, on this general plan, carries plates 8 x 10.

PHOTOPHANE.—A secret photo-mechanical process very similar to the Collotype.

PHOTO-RELIEF ENGRAVING.—Processes in which, by photography and subsequent manipulation, a printing surface is obtained, which stands above the general surface, and receives the ink in the same manner as type. Wood-cuts come under this heading. The Woodbury process is often termed a photo-relief one, although here the image itself is in relief, the printing block being an intaglio plate.

PHOTO RELIEFS.—Images in relief produced by photography, and largely employed in photo-mechanical printing processes. The simplest method of making a relief is based on the peculiar property of dichromatized gelatine to become insoluble when acted upon by light. If we take a glass or a sheet of paper coated with a thick film of dichromatized gelatine and expose it beneath a negative, those parts situated beneath the transparent parts of the negative image lose their solubility, while the parts not affected retain it. The remaining parts or half-tones of the negative allow it to be affected in different degrees, according to the amount of their transparency. If the exposed gelatine film be laid in cold water, only the soluble or unaffected parts will swell up, the insoluble portions remaining the same. By this means we get a true relief. From this a casting may be made, and electrotype printing blocks produced.

If the exposed film be laid in hot water, however, we have already explained that the unaffected parts will dissolve away. In Fig. 344 we are able to see in a clear manner the action

FIG. 343.—MERCER'S MICROSCOPIC CAMERA.

that takes place. A represents a negative, portions being opaque, others transparent, and parts varying in opacity; these are the half-tones; B is the dichromatized gelatine film after exposure under the negative, the dark parts representing the action of the light in rendering the gelatine insoluble. If this be placed in cold water the unexposed portions will swell up above the others, as shown in C. If, however, it be laid in warm water the soluble parts will then dissolve, and the relief will then have the appearance of D. It will be noted that here the half-tones are lost; they have no support, and consequently are easily detached and torn away, as shown by the dotted lines. To prevent this, however, a new support is given to the gelatine, or the film may be coated on a collodion or other transparent film, and exposed on the reverse side under the negative. We then get a result as shown in D.

If we compare C with E we shall see that by the two processes, *i.e.*, the application of cold and hot water, we get two opposite kinds of reliefs; in the first the unexposed parts stand out in relief, but in the latter case it is those which have been exposed to the light.

If a gelatine relief be pressed into lead, any number of images on pigmented gelatine can be made from the mould thus produced. This is the basis of the Woodburytype process. For other photo-mechanical half-tone processes the image must be broken up into a fine grain. This is sometimes done by putting the gelatine relief into fine sand. For detailed instructions in relief making see **Woodburytype.**

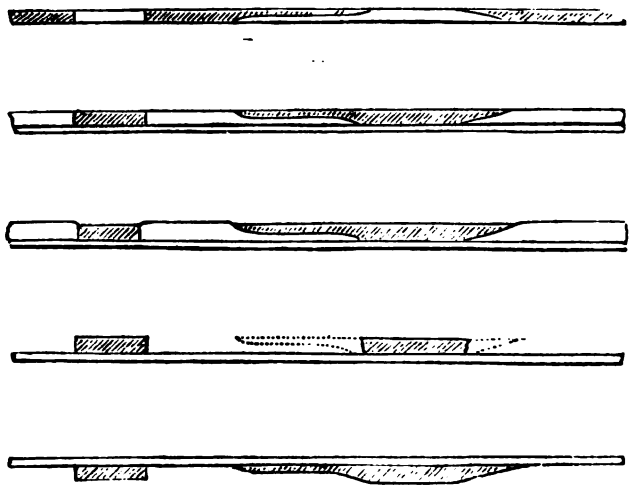


FIG. 344.

PHOTO SALTS.—A term applied by Carey Lea to the colored haloids obtained by him in his researches in the photo-chemistry of the silver haloids. These photo salts, described by him under the names of photo-chloride, photobromide, and photo-iodide, are produced by reaction such as would tend to give rise to the formation of sub-salts (supposing these to exist) in admixture with the normal haloids.*

Lea has given them the name of photo salts because he considers that they are identical with the products formed by photo decomposition. They contain less halogen than the normal haloids, and many reasons are adduced in support of the view that the latent photographic image is formed of these photo salts. Up to the present experiments have not been carried sufficiently far to enable one to speak with any degree of certainty; but it is not at all improbable that this will lead to the correct theory of the mysterious latent image.

PHOTO-SCULPTURE.—A process for producing statuettes by the aid of photography, invented by M. Villème, a well-known French sculptor. The model stands in a studio specially constructed for the purpose in the center of a circle of twenty-four cameras. By an electric attachment the series of twenty-four photographs are made at the same moment. These are projected in succession upon a screen by means of the optical lantern, and the artist goes over the outline of each with the tracer of a pantograph, the pencil end being substituted by a cutting tool acting on a lump of modelling clay mounted upon a regulating turn-table. After each photograph is traced the clay is turned through 15 deg. When it has completely revolved, and all twenty-four photographs gone over, the clay is removed and finished by hand.

PHOTO-SPECTROSCOPY.—See **Spectrum.**

PHOTOTINT.—A photo-mechanical printing process similar to Collotype.

PHOTOTYPE.—This name was formerly given to a secret process of carbon printing invented by M. Joubert. It is now applied to a method of Collotype or Albertype printing and to blocks produced by any photo-typographic process.

PHOTO-TYPOGRAPHY.—A general term applied in photography to a large number of processes in which printing surfaces are made by the aid of light.

PHOTO-ZINCO ENGRAVING.—See **Photo-zincography.**

PHOTO-ZINCOGRAPHY.—A process very similar in detail to Photo-lithography (*q.v.*). Instead of the stone, however, the image is transferred to a zinc plate. The method of making the transfer has already been described under the heading just referred to.

* See Meldola's "Chemistry of Photography."

Zinc plates for this purpose can be purchased, ready for use. They should be about 10 B. W. gauge. The first operation is to grain them with a zinc muller and fine sand. Brass-founders' moulding sand sifted through a fine sieve is the best for use. A little of it is laid on the plate, placed on a flat surface, and water poured on. The zinc muller is then worked slowly round and round until the entire surface appears after washing of a dull gray color. All scratches must be carefully ground out and grit avoided.

This operation should be performed immediately before the plate is required for use. The transfer of the image is similar to the operation described in the photo-lithographic process. The transfer is damped and passed through the press, the zinc plate being previously screwed on to a block of hard wood planed perfectly true. After removal of the transfer the plate is well washed and fanned until dry. The etching solution is composed of :—

Decoction of galls	1 quart
Gum water	3 quarts
Phosphoric acid	3 ounces

(See also **Photo-engraving.**)

PHTHALIC ANHYDRIDE (Formula, $C_6H_4(CO_2H_2)$.—Prepared by oxidizing naphthalene tetrachloride with nitric acid. It is sometimes used in the manufacture of eosine and of phenol phthalein.

PICRIC ACID (Formula, $C_6H_2(NO_2)_3OH$; synonym, *carbazotic acid*).—Prepared by the action of nitric acid on phenol. It takes the form of yellow plates or prisms, sparingly soluble in cold water, but more easily on heating, giving it a bright yellow color ; alcohol dissolves it readily. It has been used as a ray sensitizer in the orthochromatic process. It is sometimes used as a test for potassium, as its potassium salt is very slightly soluble in cold water.

Prof. W. K. Burton has pointed out the following uses of picric acid in photography:

Staining plates to prevent halation.—It was from a French source that I gained the first hint as to this use of picric acid, but I cannot at this moment remember the authority.

A cold saturated solution of picric acid is made—picric acid is soluble in cold water to about the extent of one per cent.—and ammonia is added till the solution distinctly smells thereof. Plates dipped for two minutes or so in this solution and dried resist halation to a remarkable extent. To give some idea of the amount of resistance given by this treatment, I may say that it is about as difficult to produce halation on picrated plates as on the Sandel *double* coated plates, but not nearly so difficult as on the *triple* coated plates of the same make.

The exposure is prolonged a little, but not much, if due precaution be taken in the development, but such precaution must be taken. The reason is that the picrate of ammonium in the film acts as a very powerful restrainer, and that, if the usual developer be used, we get a very hard negative, giving the impression that it was much under-exposed. A developer that is commonly used with a restrainer—pyro with ammonia for example—may simply be used without the restrainer. A good developer is eikonogen with a large quantity of carbonate of soda and no restrainer. The following may be used:

Eikonogen	10 grains
Soda (crystallized)	25 grains
Sulphite of soda	25 grains

to each ounce of developer.

There can be no doubt that a plate useful for many purposes could be made by adding picric acid to the emulsion before coating. The quantity of picric acid needed does not add appreciably to the cost of the emulsion.

Picric acid for orthochromatizing plates. This is not one of the *uses* of picric acid, for picric acid has no orthochromatizing effect, yet I have several times seen it recommended for this purpose. I cannot very well understand why it should have been recommended, as it is the very last coloring matter that might be expected to have the desired effect. It has long been demonstrated that dyes sensitize to those parts of the spectrum that they absorb. Now, as will be seen presently, picric acid, or picrate of ammonia, absorbs the extreme violet and violet-blue of the spectrum only, the very parts the sensitiveness of which we have to *repress* in orthochromatic work.

The fact that such dyes as have an orthochromatizing effect, sensitize to the parts of the spectrum that they absorb, is better illustrated in the case of cyanine than in that of any other dye that I have experimented with. This is probably because the absorption band is so very clearly marked in the case of this dye. If the light passing through a solution of it be examined by the spectroscope, it will be seen that there is a very well marked band of complete absorption extending from the orange-yellow, through the orange into the red, but not extending to the extreme red.

I may mention that for sensitizing to the whole of the visible spectrum (with the exception of the extreme red, to which ordinary plates are not sensitive, namely, to green, yellow, orange

and red) a mixture of cyanine and eosine has a better effect than that of any one dye or other combination of dyes that I have tried. Plates so sensitized are very useful for copying pictures of some kinds. To get the maximum effect, the plates are first dipped in a *very weak* solution of nitrate of silver for five minutes, and then in a solution of the two dyes.

Plates treated in this way come nearer to the great desideratum of a plate that will give true color values without a color screen than any other that I have tried. Even in copying difficult pictures the very lightest screen is sufficient, or it will do to work in gas or lamp-light without a color screen.

The plates are very difficult to work, however, and I have no idea whether they will keep or not. I have always used them either wet or soon after they were dry.

Picric Acid for Color-Screens.—Picric acid (or picrate of ammonium) would appear to be of exactly the right color for color-screens to be used for orthochromatic photography.

It should always be borne in mind, in this connection, that we want to cut off with the color-screen the greater part of the violet light, a great part of the violet blue, and some of the blue, but none of any other color. Now most color-screens—notably those made with aurine—are really of a very dilute (if the term may be permitted) orange yellow color. This means that they cut off some green and yellow light as well as some blue and violet. This the light lemon color of picric acid does not do.

The following experiment is an instructive one. A plate is coated with a solution of gelatine and picrate of ammonia in the manner described further on, but the coating is made thick at one end, thin at the other. This is done by slipping a thin wooden wedge under one end of the plate, while the latter is on the leveling slab, till the solution has left one end entirely, or almost entirely.

This plate, when dry, is examined by the spectroscope, placing it between the spectroscope and the light and slowly passing it along, so that the light passes first through the thinnest part of the film, last through the thickest. The appearance is that the light is gradually cut off from the extreme violet end of the spectrum. First the extreme violet goes, then the violet, then the violet blue, and with the thickest film possible to make in the way described, the greater part of the blue, but no other color is perceptibly affected, not even the blue-green. I have an advertisement printed in a violet-blue ink—a pure violet blue, not a mixture of blue and red; evidently an aniline, or at any rate a coal-tar product—color. This, looked at through a moderately thick picrate film, looks as black as printers' ink.

A comparison of picric acid and aurine was made by the aid of a cell with plate glass sides, solutions of the two substances being used. The picric acid was found to be immeasurably superior to the aurine. The highest tinge of it had as great an effect as quite a deep colored solution of aurine, and, moreover, the picric acid gave truer color values than could be got by *any* strength of aurine solution.

A glass cell filled with a solution is an excellent thing for experimental work, but it is most awkward for practical work. This set me to work to try to make picric acid screens. All attempts to get a clear, transparent film with varnish or collodion failed. The films were always muddy. At last the following method was found successful:

As for dipping plates, a cold, saturated solution of picric acid is made, and ammonia is added till picrate of ammonia is produced, as indicated by the smell of ammonia;* to each ounce of this solution are added 10 to 15 grains of hard gelatine. This is allowed to swell, and is melted by heat. Four or five per cent. of alcohol is added, the solution is filtered through cambric, and *patent* plates are coated with the solution, exactly as dry plates are made by coating with gelatine emulsion.

Plates of different intensity can be produced by giving different thickness of coating. A very thin coating only is needed for orthochromatic purposes with any orthochromatic plates I have ever used. With thickly coated plates very fair orthochromatic results can be got on ordinary dry plates, but of course with a very greatly increased exposure.

When the picric plates are dry they should be varnished with great care.

It may be objected that "patent plate" is not true enough for color screens; that only "optically ground" surfaces are good enough, and it is quite true that screens made as I have described, and used near the lens, either in front of or behind it, perceptibly degrade the definition. To overcome this difficulty, the screens are made of the full size of the plates to be used, and are placed in the dark slide in front of the plates to be used, picrate film to gelatino-bromide film, an adjustment equal to the thickness of the screen being, of course, made after focusing unless a special dark slide is used. Working in this way there is no perceptible degradation of definition.

It is to be feared that in these degenerate days it is not every photographer who can coat plates with the perfect evenness that is necessary for this kind of work. I believe professional plate makers might find it pay them to coat such plates of the standard sizes and of different intensity.

*In the case of a solution to be used for dipping dry plates in, the necessity for adding ammonia is evident. The presence of an acid in the film would be objectionable. The advantage of the ammonia in a solution for the manufacture of color-screens will not at first be evident, picric acid and picrate of ammonia giving solutions of exactly the same color, but my assistant, Mr. Arito, has shown that a much clearer, more transparent screen results with picrate of ammonium than with picric acid.

It may be objected that two plates cannot be inserted in most dark slides in the way described. They cannot in all kinds of dark slides, but they can in most; though in the case of many double dark slides only one picrate screen and one dry plate can be used in each.

Picrate Plates as Dark-room Lamp Media.—I have made a few experiments with a plate coated with the solution above described, as the transparent medium for a dark-room lamp. The plate was rather thinly coated. The light appeared nearly as white as that of common gas without any shade; but with the same amount of *visual* light, it was found to be *very* nearly as safe as the light filtered through red flashed glass that had been picked out of a large quantity by spectroscope tests as being particularly safe, and the light yellow light is much the more pleasant to work in.

I am proceeding with experiments with plates more thickly coated and with several in front of each other. I hope thus to get illumination of a light yellow color that it will be a pleasure to work with, and that will be at least as safe as any other kind of light.

PIGEON POST.—See **Military Photography.**

PIGMENT.—A coloring material.

PIGMENT PRINTING.—This is a term sometimes applied to the carbon or autotype process, because the image consists entirely of a pigment held in gelatine. The tissue can be obtained with various pigments, the chief are standard brown, engraving black, sepia, and red chalk. The first gives the ordinary photographic tone, the second is used for copies of drawings, engravings, etc., in black and white, and the sepia is suitable for reproducing sepia drawings, or for portraits on canvas to form the basis of oil painting, while the red chalk gives the tone of a red chalk drawing, or a print in Bartolozzi red. Other colors can, of course, be obtained incorporated with the gelatine, the resulting image, being, of course, in that color.

FIG. 345.—PIN-HOLE PORTRAIT.

PINHOLE PHOTOGRAPHY.—It is a well-known fact that, although the lens is the most important part of the photographic apparatus, pictures can be made entirely without its use Very passable negatives can be made by means of a small hole in a rectangular light-tight box, and a plate fixed at the other end, or the lens can be moved from the camera front and a piece of tinfoil in which a small hole has been made can be substituted It is usually stated that no focusing is required—the larger the plate the wider the angle, and the greater the distance the larger the image—but according to Professor Pickering 12 inches is the maximum distance for sharp work. He found that the shorter the distance the better the definition, and, further, that the size of the hole is regulated by the distance. At 12 inches the best results are obtainable with a hole $\frac{8}{100}$ in. in diameter. If it be made

FIG. 346.—PIN-HOLE LANDSCAPE.

any smaller than this the image will suffer by diffraction, and if any larger it also becomes blurred and indistinct. A general rule may be laid down that with short foci the aperture should in no case exceed $\frac{1}{50}$ in., or be less than $\frac{1}{100}$ in. The hole itself requires to be very carefully made to get the best effects. There must be no burr. This must be removed. A very simple method of avoiding its formation is to burn the hole in a piece of black paper with a red-hot needle. The accompanying illustrations were made by Liesegang.

PINHOLES.—Tiny transparent spots visible in the negative.

In the collodion process they are caused by the silver solution, which is added to the developer, dissolving out the iodide from the film. Unless the preservative be well filtered the same defect may also occur.

In the gelatine dry-plate process, pinholes may be due to tiny air bubbles in the emulsion, or from dust in the dark slide settling on the plate previous to exposure. In the former case the pinholes will be represented by clear glass, and in the latter by transparent emulsion. To prevent air-bubbles in the emulsion, it should be allowed to settle for some time, and the top skimmed off before using.

Before laying the plates in the dark slide they should be dusted over with a broad camel-hairbrush. Abney further recommends rubbing the interior of the dark slide with a minute trace of glycerine, which acts as a trap for the dust and prevents it from settling on to the plate.

PINS.—Pins are used in photography for hanging up papers to dry, or for pinning the corners to a board. For pinning up silver sensitized paper, pins silver plated or coated with enamel should be used, otherwise the metal when in contact with the silver chloride will cause it to turn black at those parts.

PINT.—A measure of capacity for liquid = 34·69525 cubic inches. It is equivalent to 20 ounces liquid measure, and is the eighth part of a gallon in England. In U. S. a pint = 16 fluid-ounces or 28·875 cubic inches.

PIPECLAY.—Formerly used instead of kaolin for decoloring old nitrate baths.

PIPETTE.—A little instrument for measuring liquids in drops. A simple method of constructing one is to take a glass tube about ten inches long, and about three-eighths of an inch in diameter. This is heated in the middle with a spirit lamp, constantly turning it round to prevent uneven expansion. When quite soft it is pulled apart suddenly, the separated parts being drawn out into very fine points. Break off one of these points, and a tube with a fine aperture is obtained; the further the glass is broken away the larger the aperture. It now only remains to fit on to the other end a piece of India-rubber tubing and close the end up with a cork; the apparatus is then complete, but the size of the drop it will deliver is uncertain, and must be tested before using.

PITCH, JEW'S.—The same as asphaltum (*q. v.*)

PIZZIGHELLI'S PROCESS.—See **Platinotype**.

PLAIN PAPER, PRINTING ON.—Plain paper may be printed on and made to yield very artistic results. For this purpose we require a good class of paper, such as Saxe or Rives. This is sized with gelatine or albumen. A very good formula is the following:

Albumen	1 ounce
Water	16 ounces.

This is placed in a strong bottle with some pieces of broken glass, and well shaken up until all the flocculent matter is cut up. It is then strained through muslin, and ten grains of ammonium chloride added to each ounce of the solution. This solution is then filtered again and placed in a shallow dish somewhat larger than the paper to be prepared. A strip of blotting paper or board, a little longer than the width of the dish, is then drawn edgeways along the solution, just touching it so as to skim off air-bells, dust, and foreign particles floating on the surface. A sheet of the paper is next immersed in the solution for about a minute, when it is withdrawn quickly and hung up to dry. When it is perfectly dry it is floated on the solution for about two minutes. With most papers there is a right and wrong side, so that this must be detected before laying on the solution. Paper prepared in this manner can be kept any length of time.

The sensitizing bath is made up of

Water	10 ounces-fluid
Silver nitrate	500 grains
Sat. sol. sodium carbonate	10 to 15 drops

The sodium carbonate solution is added until a slight precipitate is formed. Give the bottle and its contents a good shaking, and after allowing it to settle it will be ready to use. If it is clear it can be decanted into the dish ready to receive it.

Those accustomed to silvering albumen paper will not find any difficulty in the next operation, that of sensitizing. The paper is gently laid on the surface of the solution in such a manner as to prevent the formation of air-bubbles, and also to prevent the solution from coming on to the back of the paper. Gently raise each corner of the paper separately, and examine for air-bells; these can be removed with a glass rod or the clean tip of the little finger dipped in the solution, and the paper returned to its position. After about three minutes it is removed and hung up to dry. The silver bath must be kept at a correct strength, and will require to be renewed from time to time with nitrate of silver, it must also be kept neutral, which it will do so long as there remains an excess of silver carbonate.

Printing is done in the ordinary way under a negative in the printing frame. To get very deep effects the paper can be fumed for about fifteen minutes with ammonia. Print rather deeper than required for the finished print to allow for the reduction in density that takes place in the subsequent toning and fixing operations.

The toning process is accomplished with any toning bath. The most suitable, however, are those which give black engraving-like tones.

The following bath gives very good sepia tones:

Make up the following stock solution

Gold trichloride	15 grains
Water	8 ounces

For use take about an ounce of this and add sufficient of a saturated solution of sodium bicarbonate to completely neutralize. Add to this 50 ounces of clear water and about a quarter of an ounce of common salt, shake up well, and the toning bath is ready. Tone the prints to a deep purple, and fix in a 1 in 8 solution of sodium hyposulphite for about fifteen minutes. Well wash and dry between blotting boards. Prints of this description should be mounted on large mounts to give plenty margin round the picture.

Very pretty effects may be obtained by printing under a mask, so as to give a broad white margin, which may, if desired, be afterward tinted by laying a disc over the print and exposing the margin to the light until the required tint is obtained. With some subjects very good effects are made by allowing the margin to get quite black. With most papers small black spots are often visible after sensitizing, due to fine pieces of metal imbedded in the paper pulp. These can usually be removed with a sharp-pointed penknife.

Another simple method of obtaining plain silver prints somewhat resembling platinotypes is by sensitizing an ordinary sheet of albumen paper face upwards on the silver bath and using the back of the paper for printing on.

Burton recommends the following formula for prints on drawing paper. The results are said to be remarkably fine and of black tone.

SALTING SOLUTION.

Chloride of ammonium	50 grains
Gelatine	100 grains
Water	10 ounces

This was warmed, and 2 ounces of negative varnish were added.

SENSITIZING SOLUTION.

Nitrate of silver	2 ounces
Water	10 ounces

TONING SOLUTION.

Chloroplatinite of potassium	15 grains
Citric acid	50 grains
Water	25 ounces

FIXING SOLUTION.

Hyposulphite of soda	2 ounces
Water	10 ounces

PLANE PERSPECTIVE.—The surface upon which the objects are delineated or the picture drawn, also termed the plane of projection or the plane of the picture.

When the plane of the picture is parallel to the side of the principal object in the picture it is termed *parallel* perspective.

When the plane of the picture is supposed to be at an angle to the side of the principal object in the picture, as, for instance, a building, it is termed oblique perspective.

PLANO-CONCAVE LENS.—A lens having one side concave, and the other side plane It causes parallel rays to diverge.

PLANO-CONVEX LENS.—A lens having one side convex and the other side plane. It causes parallel rays to converge to a point termed the focus.

PLANO-CONICAL.—Plane on one side and conical on the other.

PLANO-ORBICULAR.—Plane on one side and spherical on the other.

PLASTER OF PARIS—(Synonym, *gypsum.* An hydrous calcium sulphate, "gypsum" is the *unburned* rock.—Sulphate of calcium, sold as a white powder), almost insoluble in water. If mixed with a small quantity to form a paste, it gradually thickens, and afterward solidifies to a hard mass of hydrated sulphate. Owing to this property it is largely used for making casts or moulds. It is also very useful for mending leaks or repairing broken articles. It should be kept in air-tight stoppered jars, and if stale, heat to 400°F before using.

PLATE.—In optics this term is applied to transparent media bounded by parallel surfaces. The term is generally used in photography to denote the support for the sensitive medium, as Daguerreotype-plate, collodion-plate, dry-plate, ferrotype-plate, etc.

PLATE BOX:—A box arranged for the reception of photographic plates. Two sides are grooved with an equal number of grooves; into these the two ends of the plate slide, and are just prevented from injuring each other by contact.

PLATE CARRIER.—A loose blackened wood frame, fitting the interior of the dark slide to enable smaller size plates to be exposed than the camera was constructed for.

PLATE CLEANING-SOLUTION.—A solution for cleaning glass plates previous to being coated with photographic substances, such as collodion or gelatine emulsions. The best known is the following:—

Spirits of wine	100 parts
Tripoli powder sufficient to make a cream like fluid	
Ammonium hydrate	2 parts

Alkalis possess the property of converting greasy into saponaceous matter, and alcohol will dissolve both soap and grease. Both are therefore employed as detergents. Another very effective detergent is a solution of potassium dichromate and sulphuric acid.

PLATE-COATING MACHINE.—A machine for coating dry plates. (See **Dry Plates.**)

PLATE GLASS.—See under **Glass.**

PLATE HOLDER.—A contrivance used to hold plates during manipulation. They were principally used in the wet-collodion process when cleaning and coating the plate. (See also **Pneumatic Holder.**)

PLATE LIFTER.—A contrivance for lifting the plate without using the fingers. A convenient form is that shown in Fig. 347.

This is sometimes of great use when the plate is required to be lifted out from chemical solutions which have an injurious effect upon the skin. It also preserves the gelatine film from mechanical injury.

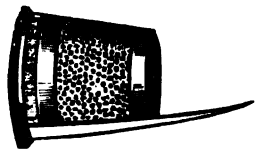


FIG. 347.—PLATE LIFTER.

PLATE PAPER.—A heavy bibulous paper used for taking impressions of engravings, photo-engravings, etc.

PLATE RACK.—A rack arranged to receive glass or other plates, which fit into grooves in such a position that all superfluous solution drains off from one corner; as they are kept slightly apart from each other, a current of air passing between will soon dry them.

PLATE ROCKER.—An arrangement for rocking the dish containing the plate in the developing solution and keeping the latter constantly flowing backwards and forwards on the negative. Several different devices have been invented for this purposes.

PLATE SHEATH.—See **Sheath.**

PLATE-SUNK MOUNT.—Mounts having a center portion pressed or sunken in. They are very effective for platinotype, bromide or plain paper tints. (See **Mount.**)

PLATE VISE.—An arrangement for holding a glass plate to more conveniently clean or polish it. See Fig. 348 and 349.

PLATINIC CHLORIDE.—See **Platinum Tetrachloride.**

PLATINOTYPE PROCESS.—A process of positive printing from the negative, giving pictures of remarkable softness and artistic quality. As far back as 1832 Sir J. Herschel gave an account of his experiments on the action of light upon salts of platinum. Later on in 1844 Hunt pointed out the fact that if a piece of paper be dipped in a solution of a platino-cyanide of potassium, and hung up to dry in the sun, no change was perceptible; but if after a short exposure it be treated with mercurous nitrate, a weak positive image was produced.

The first practical platinum printing process was, however, invented and patented by Mr. Willis, of the Platinotype Co., and who supply all the necessary materials and the paper ready sensitized. Other processes are hereafter described, however, which may be worked by anyone.

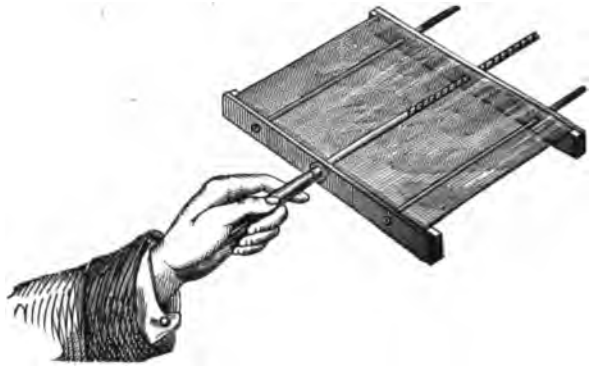


FIG. 348.—PLATE VISE.

The principles of the process may be briefly stated as follows:—Paper is coated with a mixture of potassium chloroplatinite and ferric oxalate. The ferric oxalate is sensitive to light, becoming converted into ferrous oxalate; we therefore get a faint grayish orange-colored image of ferrous oxalate. Now, ferrous oxalate possesses the power when in solution of reducing potassium chloroplatinite to metallic platinum. It, therefore, only becomes necessary to dissolve the ferrous oxalate in a suitable liquid, when the potassium chloroplatinite will be reduced to the metallic state as metallic platinum.

FIG. 349.—PLATE CLASP.

A solution of potassium oxalate possess this requisite power of dissolving the ferrous oxalate. The paper prepared with the chloroplatinite of potash having an image on it of ferrous oxalate is, therefore, floated on this solution, and a picture consisting of finely divided metallic platinum is the result obtained. It then only becomes necessary to dissolve away the remaining iron salts by any suitable acid. The following reactions (according to Berkely) take place:—

$$Fe_2(C_2O_4)_3 = 2FeC_2O_4 + 2\ CO_2$$

$$6Fe(C_2O_4) + 3K_2PtCl_4 = 2Fe(C_2O_4) + Fe_2Cl_6 + 6\ KCl + 3Pt$$

Metallic platinum being one of the most stable substances known, it is probable that prints by this process are absolutely permanent.

Preparation of the Paper.—The paper is first treated with a size to prevent the sensitizing solution from sinking too deeply into it. A good stout paper is required of even texture and pure in color.

150 grains of moderately hard gelatine are dissolved in 30 ounces of water, and 45 grains of alum, together with seven ounces of pure methylated spirit, are added. This is then filtered into a conveniently large dish, and the sheets passed through it one by one and hung up to dry. When dry it may be passed through a second time and dried. If arrowroot be used as the sizing browner tones are obtained in the finished prints.

Coating the Paper.—The next operation is the coating of the paper with the sensitive solution. This should be done in a darkened room, care being taken that the sensitized paper be exposed for the shortest possible time. Lamplight, owing to its yellow color, is not suitable, as the coated parts cannot be easily distinguished from the uncoated.

Captain Pizzighelli and Baron Hubl in their work on the subject* give the following methods of preparing the paper, the variations being made to suit the different class of negatives. These two solutions are prepared—

No. 1.

Ferric oxalate	120 grains
Water	1 ounce
Oxalic acid	8 grains

No. 2.

No. 1 solution	1 ounce
Chlorate of potassium	2 grains

Considerable care must be taken that both these two solutions are protected from actinic light, otherwise the ferric salt will be speedily reduced to the ferrous salt.†

* "Platinotype," by Captain Pizzighelli and Baron A. Hubl, translated by J. F. Iselin, and edited by Captain W de W. Abney. R E., F.R.S.

† This can be detected by taking a few drops on a glass plate and mixing with it a drop of a solution of ferricyanide of potassium. If any blue coloration takes place there has been a reduction, and consequently the solution is unfit for use.

The sensitizing solution is prepared as follows:

Potassium chloroplatinite solution (80 grains to 1 ounce of water)	24 drachms
No. 1 solution	22 drachms
Distilled water	4 drachms

This should give very soft and deep black prints. If greater brilliancy is required the following is recommended:

Chloro-platinite solution	24 drachms
Solution No. 1	18 drachms
" No. 2	4 drachms
Distilled water	4 drachms

The next solution is recommended when results corresponding to silver images are required—

Chloro-platinite solution	24 drachms
Solution No. 1	14 drachms
" No. 2	8 drachms
Distilled water	4 drachms

For very weak negatives, reproductions of engravings, etc., use—

Chloro-platinite solution	24 drachms
No. 2	22 drachms
Distilled water	4 drachms

The addition of the No. 2 or chlorate of potash solution increases the contrast, as it reduces a portion of the platinite into a platinic salt. It will be obvious, therefore, that by a judicious use of it brilliant prints may be obtained even from weak negatives. If the pictures possess no black shadows, as, for instance, in the reproduction of pencil drawings, the above mixtures may be diluted with half or even equal volumes of water. Distilled water should always be used.

Just before using, sufficient quantity of one of the mixtures given is prepared in a measuring glass for the size of the sheet of paper to be coated. For a sheet of paper 24 × 18, about two ounces of the solution will be required. It is applied to the surface of the paper by means of a pad of cotton wool enclosed in a piece of soft flannel. The paper must be kept flat upon a level surface. A simple method is to streteh a long piece across a table, the ends overlapping, and having attached to them American clips tied to a kitchen poker or other suitable weight, as shown in Fig. 000. This will keep it taut, even as it expands with the application of the wet solution. The sensitizing solution is poured poured on and immediately spread over with the dabber, until the coating is as even as possible.

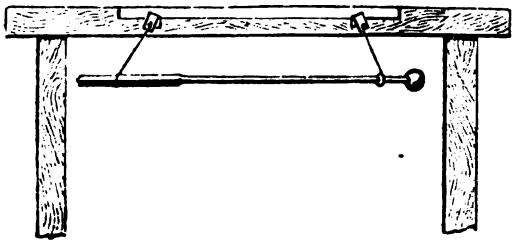


FIG. 350.

Drying the Paper.—Considerable care must be exercised in this, as much of the subsequent success is dependent upon the operation.

Directly the sheet is coated it is hung up by its corners, until all the moisture on its surface has entirely disappeared. It is then immediately dried before a fire or stove. When perfectly dry the lemon color of its surface will have changed to an orange-yellow. It should be dried perfectly without scorching, as this would produce fogged prints. It is of the utmost importance that not less than five, nor more than ten minutes should elapse between the coating and the drying operations. If it becomes dried too soon the image will probably wash away in the developer, and if not dried quickly enough the picture will be flat and sunken in. In very warm weather the surface moisture will sometimes disappear in less than five minutes. In this case the walls and floor must be sprinkled with water or the paper placed in a dampened cupboard.

Keeping the Paper.—When thoroughly dry the sheets of sensitive paper, and also the prints, are preserved in chloride of calcium boxes. Figs. 351 and 352 will serve to show the construction.

A is the compartment containing the paper. The cover B is divided into two parts, the lower part F which is placed on the the top of the box consists of a cylinder G, perforated with holes, which slides into the box A, and serves to hold some lumps of dry calcium chloride wrapped up in calico or double fold of muslin. The upper part C serves to close up the top of the cylinder G. An elastic band EE slips over the slots, and keeps them perfectly air tight. The calcium must be examined from time to time, if moist it must be changed for a fresh supply.* To secure the most brilliant results the sensitized paper before, during, and after exposure, must be kept dry as possible. The effect of damp is a want of vigor, muddy tones, and impaired purity of the whites.

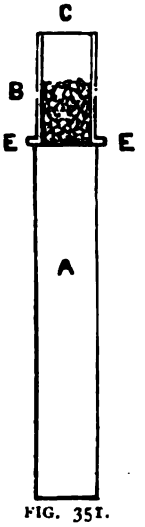


FIG. 351.

The following instructions for platinotype printing are given by Platinotype Co.:—

*Damp calcium chloride can be easily deprived of its moisture by heating in an iron vessel. It can then be used over again.

Printing.—Place the paper in the printing frame beneath the negative, and between it and the pad insert a sheet of thin vulcanized indiarubber, as it is of the first importance that the pads in contact with the paper be quite dry. The correct exposure (about one-third of that required with silver printing) is ascertained by inspection of the paper in a rather weak white light in the usual manner. A little experience will enable the exposure to be determined very accurately. The sensitized surface before exposure to light is of a lemon-yellow color. During exposure the parts affected by light become of a pale grayish-brown color, and sometimes of an orange tint under those parts of the negative which present clear glass or nearly so. As a general rule all parts of the picture except the highest lights should be visible when the exposure is complete. When examining the prints in the printing-frame care should be taken not to expose them unduly to light; for the degradation of the whites of the paper due to *slight* action of light is *not visible until after development.* Damp paper gives a less visible image than dry paper, hence it may easily be over-exposed. Remove prints to a calcium tube as soon as exposure is complete, unless they are to be at once developed.

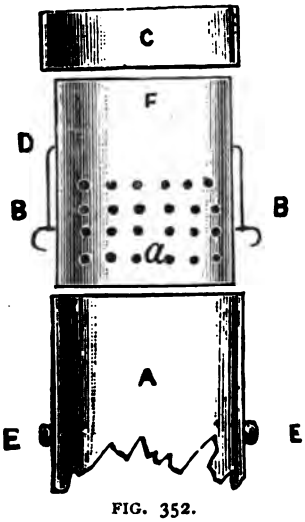


FIG. 352.

Development.—Development should be conducted in a feeble white light, similar to that used when cutting up the paper, or by gaslight. It may take place immediately after the print is exposed, or at the end of the day's printing.

The developer is made by dissolving 1 lb. of oxalate of potash in 54 ounces of water. Used hot water for making the solution, of which a large quantity may be made up; it will keep indefinitely. It is well to have at hand some unused solution, since, in the event of inferior prints being made, a new bath may at once be tried.

The solution is conveniently contained in a flat-bottomed dish of enameled iron, heated by a small spirit lamp or Bunsen burner for the smallest dish, or for the larger dishes a paraffin stove. Troughs for large prints are fitted with a tube gas-burner.

The developing tray recommended by Pizzighelli and Hübl is shown in fig. 353. A is an enameled iron vessel containing the oxalate solution: *a* its cover of zinc plate; B is another hollow vessel, with a double wall of zinc plate, which acts as a water bath; C is a gas or spirit lamp. The vessel B is filled with hot water through a little hole let into the upper side, and hot solution of oxalate is then poured into the tray A; it can readily be kept at the required temperature by means of the lamp underneath.

The development is effected by *floating the printed surface* of the paper for five or six seconds upon the "developing solution." To avoid air bubbles lay one edge of the print upon the solution near the right hand end of the dish; then, with a sliding motion towards the left, lower the print with an even movement, without stoppage, until it is entirely in contact with the liquid, where it must remain until *complete* action has taken place.

A good plan is to place the prints, after removal from the printing frames, in a calcium tube, with their printed surfaces outwards, and, therefore, convex. In a short time the prints will receive and retain this curvature sufficiently for the developing operation. To develop take the print in the right hand (its printed surface being downwards), lay the left-hand edge on the developer, and then slowly and continuously lower the right hand until the whole print is floating. The great point is to well preserve, and if possible increase, the curvature of the paper as it near the liquid.

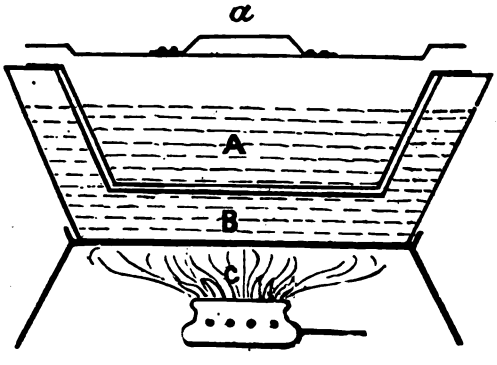


FIG. 353.

A temperature of about 140 deg. Fahr. may be considered the standard temperature for the developer, though higher and lower temperatures may be used on occasion. To test the temperature a cheap chemical thermometer must be used. The bottom of the developing dish should be covered with the developing solution to the depth of *at least* one-half of an inch.

After the prints have been developed put the solution, without filtering, into a bottle for future use; it should not be exposed to a strong light. When next developing the solution will be found to be *nearly clear, but, of course, tinted by previous use.* If this clear solution be not sufficiente for use, add to it some of the fresh solution of the potassic oxalate. It is a safe plan always to *keep the "bath solution" up to its original bulk* by this means. A little suspended matter in the bath is not of any consequence.

Sometimes, when a *large number* of prints (or *large prints* upon *small bulk* of solution) are developed at *one operation*, the bath will become so loaded with chemicals derived from the paper

that it will no longer give good prints. Such a solution must at once be replaced by a new one. When working on a somewhat large scale it is especially necessary to watch for any change in the quality of the prints; and in case of a doubt a new bath should be tried.

Very large prints may be developed without any difficulty in a trough, by being *slowly and continuously pulled through* the solution contained therein.

Clearing and Washing.—To clear the developed prints; these must be washed in a series of baths (not less than three) of a weak solution of hydrochloric acid. This solution is made by mixing 1 part of hydrochloric acid with 60 parts of water. The specific gravity of the acid should not be less than 1·16; if lower, more acid should be used. The acid should be colorless. Or citric acid, in the proportion of 1 ounce to 20 ounces of water, may be used This softens the paper in less degree than does the hydrochloric acid. *A white opalescence of the bath shows necessity for more acid.*

As soon as the print has been removed frem the developing dish it must be *immersed face downwards* in the first bath of this acid, contained in a porcelain dish, in which it should remain about five minutes; meanwhile, other prints follow until all are developed. The prints must then be removed to a second acid bath for about ten minutes; afterward to the third bath for about fifteen minutes. While the prints remain in these acid baths they should be moved so that the solution has free access to their surfaces, but care should be taken not to abrade them by undue friction. It is impossible to affect the image *per se* by leaving the prints for a long time in the acid baths, but such treatment continued for an hour or more tends to make the paper soft and porous, and to damage its surface.

The prints should not communicate to the last acid bath the slightest tinge of color. If the bath, after the prints have been washed in it, does not remain as colorless as water when a depth of fully two inches is viewed in full daylight, the prints should be treated to yet another acid bath. The last acid bath must not in any case have been used for a previous batch of prints; after use it may form the first acid bath for the next batch, but it is better to replace all the baths by fresh ones. The object of this washing in dilute acid is to remove all traces of iron salts from the paper before it is placed in the plain water. The prints must not be placed in plain water on leaving the developer, because insoluble salts will be precipitated on the print. After the prints have passed through the acid baths they should be well washed in two or three changes of water during about a quarter of an hour. It is sometimes advisable to add a pinch of washing soda to the second washing water to neutralize any acid present in the print.

Drying and Mounting.—After drying the prints are dried in the ordinary way. Any mountant can be used that does not show through the print. Gelatine alone is not suitable except for thick paper. Thick cold starch, or starch and gelatine, are the best mountants.

Platinum prints appear somewhat more brilliant and lighter when wet than when dry; therefore, if it has a correct appearance as regards tone when wet, it will be too dark when finished. Prints on smooth paper may be hot-pressed, which gives them a slight sheen, and brings up the dark parts. They may also be retouched with colors or chalk, their smooth, heavy surface serving well for this purpose.

The following list of defects and their remedies is given by Captain Pizzighelli and Baron Hübl:

1.—The pictures are vigorous, but more or less fogged.

(*A*) *cause:* The paper was affected by light either in sensitizing or printing.

To prevent it sensitize only under a weak light, and dry either in complete darkness or by lamplight. When examining the course of the copying operation be careful to avoid too strong a light in arranging the frame.

(*B*) *cause:* Too high a temperature in drying.

It should never exceed 40 deg. C.

(*C*) *cause:* Spoiled ferric solution.

The ferric solution is best preserved from the influence of light by being kept in a hyalite flask. If you are not confident as to your solution, you must assure yourself before using it by testing with red prussiate of potash that it is free from ferrite. Should it only contain a trace of ferrite it can be made fit for use again by carefully adding red prussiate of potash. In order to try this, mix a few cubic centimetres of the normal ferric chlorate solution with every 100 cubic centimetres of the iron solution, and ascertain by actual experiment on paper whether the restoration is complete.

(*D*) *cause:* Too long exposure in the printing frame.

The time of copying should be shortened, and if the picture is not yet developed use a cold developer.

2.—The prints appear too weak under the developer.

(*A*) *cause:* Paper which has become damp.

The paper should always be kept in the calcium chloride boxes, even after being printed, if not immediately developed. Paper once spoiled cannot be made good again.

(*B*) *cause:* The paper is too old.

Paper can generally be kept in good condition for, at least, six or eight weeks, and some-

times even more; but after that time even a gradual change appears to take place, even though it be kept in the dark, and not only weak, but also fogged pictures are the result. As neither time nor trouble are required for sensitizing the paper, we recommend only to make at once as much as may be necessary for use during three or four weeks.

(*C*) *cause:* Weak negatives.

Use more chlorate of potash in the sensitizing solution.

3.—The prints come out vigorous in developing, but become weak after being dried.

Paper not sufficiently sized, for which reason the image sinks into its substance. When this is the case employ stronger solutions of gelatine or arrowroot.

(*A*) *cause:* Drying has been too slow.

The drying process should not take longer than ten minutes; if this is exceeded the sensitizing solution sinks too deeply into the paper.

4.—The whites of the prints have, after drying, a more or less yellowish tinge.

(*A*) *cause:* The sensitizing solution in the developer is not sufficiently acid. Attention should be paid to the instructions on this point in the previous divisions of the subject.

(*B*) *cause:* Insufficient immersion in hydrochloric acid.

The solution ot hydrochloric acid must be changed two or three times, until the last change no longer turns yellow at the end of ten minutes.

(*C*) *cause:* Paper blued with ultramarine, which, when treated with hydrochloric, turns yellow.

Before using the paper you must be certain that its color does not suffer from contact with a hot solution of oxalate, and from treatment with hydrochloric acid.

5.—The prints come out hard.

(*A*) *cause:* Exposure too short.

(*B*) *cause:* Too much in the sensitizing solution. Remedy obvious.

6.—Spots and streaks.

Causes: Dirty brushes; touching the paper with wet fingers; dirty glass plates; vessels not kept clean, etc.

7.—Black spots.

(*A*) *cause:* Particles of metal embedded in the substance of the paper, causing a reduction of the platinum.

(*B*) *cause:* May be due to insoluble impurities in the chloroplatinite of potassium. These spots have a black nucleus, with an extension like the tail of a comet, of lighter color.

In such a case filter the sensitizing solution.

Platinotype prints may be made upon many other materials besides paper. Linen or other fabrics are treated in the same manner as paper. To keep smooth it should be stretched on a suitable frame after the second coating of the gelatine sizing solution. To print on wood it should be planed perfectly smooth and then coated with the gelatine solution. Thin sheets should be kept between two boards to prevent them from warping.

Sepia Platinotype Paper.—This is a special paper prepared by the Platinotype Co. for giving sepia-toned pictures. It is believed that this result is obtained by the use of a salt of mercury with the platinum. With a few exceptions all the operations are similar to the ordinary kind of platinotype paper. The following special instructions are given:—

The sepia paper is more easily affected by faint light, and, therefore, increased care must be taken during the printing operation.

To develop, add to each ounce of the potassic oxalate solution one or two drachms of a special solution supplied for the purpose, and proceed as described for ordinary platinotype paper. The temperature should not exceed 150 degs. to 160 degs. Fahrenheit. The developing bath should be kept in the dark, and must on no account be used for black prints. Discoloration of the white of the image is due to one of the following causes—(1) Want of sufficient "special solution" in the developer; (2) too much exposure of the developing solution to light; (3) use of a dish is which the enamel is cracked so as to expose the iron; (4) paper kept too long: (5) exposure of prints to too much light while clearing. The print are cleared with an acid bath of one part of hydrochloric acid (sp.gr. 1·16) to 60 parts of water. As the sepia prints, unlike the black ones, may be affected by light when in the acid bath, the lights being stained and degraded, the prints at this stage should be manipulated in a very weak light. The prints are damaged by being left long in the acid baths. The subsequent operations are the same as for the other kind of paper. Dishes used for sepia prints must not afterwards be used for developing black toned prints. Black and sepia prints must not be washed together in the same dish.

Cold-bath Process—A new method of platinotype printing introduced by Mr. Willis. The novel feature about this is that the platinum salt is used in the developing solution instead of in the paper. The following notes concerning it are given by the inventor:

Paper is coated with ferric oxalate and a small quantity of mercury salt, then exposed to the light, and afterwards developed on a cold solution containing potassic oxalate and potassic chloroplatinite. The solution of ferric oxalate employed is the same as that used in the present process, both as to the strength and acidity. In each ounce of this ferric salt is dissolved from 1 to

1½ grains of salt of mercury, preferably the chloride. It is then dried perfectly, exposed to the action of light beneath a negative, then developed on a cold solution containing from 30 to 120 grains of oxalate of potash and from 5 to 15 grains of potassic chloroplatinite. The development proceeds sufficiently, slowly to allow of its being watched and stopped by immersion of the print in the acid clearing as soon as the desired strength of the deposit has been the attained. The following are the instructions given for working the paper as supplied by the Platinotype Company :—

General Treatment of the Paper.—This presence of moisture in the paper, either during its exposure to light, or afterwards and before development, is important. Excessive moisture is neither desirable nor useful. In England the moisture absorbed from the air of a cold room in winter during fifteen minutes is usually sufficient; or, in summer, about the same time in a dampish room. Sufficient moisture will be present when the paper has lost its *crispness*, but if allowed to become *limp* the moisture will be excessive. The best results are usually obtained when the paper has been damped before its exposure to light. But for reasons explained in the next section, beginners will find it better to expose in the dry state. If damped before exposure such damping should not long precede the printing.

Prints made by exposure to light of paper in a damp state, or made on dry paper and afterwards damped, will, if developed within an hour of such exposure, give the maximum of vigor, by delaying the development for some hours, the prints in the meantime being stored in a drawer wooden box, or other suitable receptacle, so that they will retain most of their moisture, then, on development, an increase of half-tone and increased warmth of color will be obtained. The modifications in the results to be secured in this way can be only roughly indicated; the experience of the printer will very soon prevent mistakes.

But should it be necessary to delay development of prints for one or two days, they must be dried (not scorched) before a fire soon after they are removed from the frames, and then stored in a calcium tube until wanted for development.

As during printing operations no necessity exists for keeping paper dry, it is very advisable on account of the ease of manipulation, to employ drawers, or flat wooden or paper boxes, one to hold unexposed paper and another to receive exposed prints. The hinged paper boxes made for holding music answer very well for the smaller sizes. This method of working from non-metallic boxes also avoids the risk of spots due to metallic dust, which is always produced during the opening and closing of a calcium tube of tin or zinc.

Exposure to Light.—This is effected in a printing-frame in the usual manner. When exposed to light behind a negative, the lemon-color of the paper receives an image of a greyish tone. Some negatives, however, present such strong contrasts that the deep shadows on the print are carried beyond the gray stage and become of an orange-yellow; this state of the image is usually termed "solarization."

The exposure is somewhat less than that required with the old process—perhaps about one-third less. The progress of the printing is observed by opening the frame in the usual manner, but care should be taken to prevent undue access of strong light. As a general rule all details observable on the exposed print are developable, and the converse of this is also pretty generally true, namely, that no details are developable which are not also visible before development. But here it should be observed that the action of light on skies is not often clearly seen unless the rebate of the negative has been previously rendered opaque by painting with opaque varnish, so that the tint of the sky may be compared with the original color of the paper which is preserved by the opacity of the "rebate." It is important to remember that if paper be exposed in a damp state the visibility of the image is less than if exposed in a dry state; the image is weaker in appearance and less of the detail in the high lights is seen. On this account beginners will find it easier to expose dry, and damp the prints afterwards. This paper is undoubtedly easier to expose correctly than paper made for the former processes, and no one should experience any difficulty after a small amount of practice has been gone through.

Development.—The developing agents are numerous, and a great variety of formulæ is possible. The best results are, however, obtained with mixtures of oxalates and bi-phosphates. The following is a good formula:

A.

Oxalate of potash	30 grains
Bi-phosphate of potash	30 grains

Dissolved and made up with water to 1 ounce.

B.

Platinum salt	30 grains
Water	1 ounce

For use add one part of B to three parts of A, although a great many variations may be made in the proportions to which these two solutions are mixed to form the developer, and by these variations different effects are produced.

The mixed developer keeps in good condition for some hours after mixing, but it afterward slowly deteriorates, and in order to secure due economy in the use of the developer, it is important to mix no more at a time than is sufficient for the prints to be developed. In developing a very large batch, perhaps the best way is to mix the whole quantity necessary, but to put into the developing-dish only sufficient to render the floating of the prints an easy matter, and then to add the remainder by degrees, as may be found necessary.

In order to develop, pour sufficient of the developer into a porcelain tray to well cover the bottom, and then float the print, with its printed surface downwards, upon the solution; after the lapse of two or three seconds it may be lifted from the solution and held in the hand. A few seconds after the print has thus been removed from the developer, it should be again similarly floated and raised; and these operations may require to be repeated, but this will depend on the strength of the print or subject.

The object of re-floating the print is thus explained. When a print is first raised from the developer, the liquid adhering to its surface contains only a small quantity of platinum salt (the developer being weak in this ingredient), and the amount of salt so taken up is usually insufficient to supply the necessary quantity of platinum pigment to the shadows and darker parts of the print; by re-floating, a fresh supply of this pigment-forming liquid is supplied, and the number of floatings required is determined by the strength of the light impression.

After the print has been twice floated it should be held in the hand, face upwards, and the process of development carefully watched. When the half-tones have sufficiently appeared, and have become free from the granulation usually visible in the first stages of development, and the shadows also are sufficiently strong, the print should be at once immersed in the acid clearing bath. In some cases it takes a full minute to complete a development, but the moment selected for arresting it is to be decided by the taste and judgment of the operator. During the progress of the development it may sometimes be noticed that the shadows are slightly rusty in color, and appear to hang back. This indicates the necessity of another flotation on the developer. Or, instead of re-floating, some of the solution may be applied to the shadows by means of a large camel-hair pencil.

A useful development, and one securing economy to small workers, is by means of a broad camel-hair brush, but it requires a little practice. The brush must be well wetted and the strokes given with fair rapidity. It is usually better to begin at the edge of a print and to let each succeeding stroke *overlap* the previous one, then, as soon as the print is covered, repeat the operation with strokes at right angles to the first series so as to render the coating as even as possible. The brush should be dipped in the developer before each stroke, or, at any rate, before every second one. And before beginning another print the brush should be washed in the developer in order to detach any salt which it may have derived from the previous print.

In using the floating method, air bells are sometimes formed on the surface of the print, but this only rarely happens when the surface is developed in its moist state. If any should appear on the print, after its first floating, they are best removed by again laying the print on the solution and then smartly sliding the print over the surface of the liquid.

A good method of floating is to lay one end or edge of the print upon the solution near the right-hand end of the dish; then, with a sliding motion towards the left, lower the print with an even movement, until it is entirely in contact with the liquid.

In order to avoid scum-marks on the prints it is very important to rock the developing dish between the development of each print. The rocking should be so managed that the developer is driven, in a wave, against the side of the dish, so that the surface scum may be broken up and sunk in the liquid.

Watzeck's Platinotype Process.—Paper is coated with

Arrowroot	1 gramme
Cold saturated solution of sodium oxalate	50 c.c.

The solution is boiled until all sediment is dissolved. It is then applied to the paper two or more times, according to the porous nature of the paper.

For black tones the paper is sensitized in

Sat. sol. potassium chloroplatinite	5 c.c.
Sat. sol. double oxalate of soda and iron	8 c.c.
Sat. sol. potassium chlorate	3 drops

For sepia tones the following proportions are taken:

Sat. sol. potassium chloroplatinite	5 c.c.
Sat. sol. double oxalate of soda and iron	4 c.c.
Sat. sol. neutral oxalate of soda	3 c.c.
Sat. sol. mercuric chloride	1 c.c.
Sat. sol. potash chlorate	3 drops

More chlorate increases the contrasts and a smaller quantity of mercury gives darker tones. The solution of double oxalate of iron and soda is sensitive to light. The best results are obtained by drying the paper at a temperature of 35 deg. C.

Pizzighelli's Printing-out Platinotype Process.—A remarkable advance in platinum printing processes, introduced by Captain Pizzighelli, by which means the print is directly produced upon the platinum paper in the printing frame. The principles upon which the process is based are the following: (1.) By adding thickening materials to the sensitizing solution, the latter is prevented from penetrating the substance of the paper. (2.) If one of the substances used as a "developer" is added directly to the sensitizing solution, a reduction of the platinum salt takes place in the printing frame itself under the influence of the moisture of the air. The advantages of this process will be at once apparent. The previous preparation of the paper is dispensed with, and the progress of the printing can be watched, and, further, the developing process is also done away with.

Preparing the Paper.—The sort of paper to be selected is unsized photographic, smooth or rough, as supplied from Rives or Saxe or by Steinbach.

Solutions of gum arabic and arrowroot have been found the best substances for holding the sensitized liquid. These are prepared as follows:

No. 1.—Gum Arabic Solution.

Gum arabic (finest white lumps)	50 grammes
Distilled water	100 c.cm.

No. 2.—Arrowroot Solution.

Arrowroot	2 grammes
Distilled water	150 c.cm.

The arrowroot is kneaded into a paste with a little of the water, and the remainder added whilst boiling, the temperature to be kept up for some minutes. The gum arabic solution is said to give the best effects.

No. 3.—Ammonium Ferric Oxalate Solution.

Ferric oxalate	20 grammes
Oxalic acid	0.5 grammes
Ammonium oxalate	18 to 20 grammes
Distilled water	150 c.cm.

No. 4.—Sodium Ferric Oxalate Solution.

Ferric oxalate	20 grammes
Oxalic acid	0.5 grammes
Sodium oxalate	50 to 60 grammes
Distilled water	150 c.cm.

The precise amount of sodium or ammonium oxalate necessary is determined by the color of the solution as the addition is slowly made. By formation of corresponding double salts the brownish gray color it at first assumes will change to a beautiful emerald green, and on a further addition of the salt it begins to get somewhat darker. Immediately this is observed the saturation is complete, and no more must be added. It should be mentioned that the addition of the sodium or ammonium oxalate should be made in the dark room. The mixture is then shaken up and filtered.

No. 5.—Sensitizing Solution.

Chloroplatinite of potassium solution (1 in 6)	24 c.cm.
No. 1 solution	22 c.cm.
No. 3 solution	23 c.cm.

Or this—

Chloroplatinite of potash solution (1 in 6)	24 c.cm.
No. 1 solution	22 c.cm.
No. 4 solution	23 c.cm.

Or the following—

No. 6.—Sensitizing Solution.

Chloroplatinite of potash	3 grammes
Sodium oxalate	3 grammes
Ferric oxalate	4 grammes
Oxalic acid	0.6 grammes
Gum arabic	4 grammes
Distilled water	50 c.cm.

No. 5 gives bluish-black tones, and No. 6 is suitable when a more brownish color is desired. The mixture is well stirred up, filtered through muslin, and prepared from non-actinic light. The coating, drying, and storing of the paper are precisely the same as already described for the ordinary platinotype paper. About ninety minims of the liquid will be required for a piece of paper 10 x 8 inches.

Printing.—There are two or three methods of printing. By the first the action of the light is continued until all the image has appeared of the same depth of tone as required for the finished print. By the second method the printing is carried out until the image is all quite

visible as a whole, although the most delicate detail in the half-tones still remains wanting. The print is then removed from the printing frame and simply kept in the dark room. After a time, varying from half-an-hour to three or four hours, the print will be found to have completed itself, for the reason that the reduction of the platinum salts once started continues in the dark. Or, instead of laying aside to complete itself, the print may in this state be developed over with a cold solution made up as follows:

Saturated solution of sodium carbonate	5 c.c.
Distilled water	100 c.cm.

until all the finest details which are wanting have appeared. A third method of printing is to continue only as long as with the ordinary platinotype paper, that is to say, until the deepest shadows are distinctly visible. The image can then be developed with any of the ordinary platinotype developing solutions.

The prints (by whichever of the methods given above they are obtained) are placed in a dilute acid bath made up with—

Hydrochloric acid	1 c.cm.
Water	80 c.cm.

and allowed to remain there until the yellow color of the paper has disappeared. They are then washed for from ten minutes to a quarter of an hour in several changes of clean water.

PLATINOUS CHLORIDE (Formula, $PtCl_2$; synonyms, *bichloride of platinum, chloroplatinous acid*).—Prepared by heating platinic chloride to 450 deg. F. and above, until it becomes insoluble in water. It forms a dingy green powder, also insoluble in nitric and sulphuric acids. It dissolves, however, in hot hydrochloric acid and in a solution of platinic chloride, yielding in the former a bright red, and in the latter a very dark reddish-brown solution. It dissolves in caustic potash, all the platinum being thrown down as platinum black on the addition of alcohol. It forms double salts with metallic chlorides. It is used in making potassium chloroplatinite for the platinotype process.

PLATINUM (Symbol, Pt; atomic weight, 197·4).—Platinum belongs to the group of noble metals in which gold, iridium, palladium, etc., are included. It is a white metal much resembling silver in appearance. It takes its name from *plata*, Spanish for silver. It possesses a specific gravity of 21·5, and usually occurs in the free state. It is obtained chiefly in Mexico, Brazil, and Siberia, and from copper ore found in the Alps. In a fine state of division it is absolutely black. Its chief properties are its exceptional stability, which is superior to gold, and its non-oxidation at any temperature. It cannot be attacked by any single acid* and only slightly by a few alkaline substances.

Platinum is now considered to be tetratomic, or, in other words, its atom requires four atoms of any univalent element to form the molecule. Formerly it was considered to be divalent, and the term bichloride of platinum is still applied to what is in reality the tetrachloride.

Platinum is now extensively used in photography in the different platinotype processes and in platinum toning.

PLATINUM CHLORIDES.—Platinum forms two chlorides, platinic chloride and platinous chloride (*q. v.*)

PLATINUM CYANIDE.—The cyanides of platinum have not been prepared in a pure state, but the salts known as platino-cyanides exceed the ferro-cyanides in the force with which they retain the platinum distinguished by the ordinary tests for it.†

PLATINUM PERCHLORIDE.—See **Platinum Tetrachloride.**

PLATINUM PROCESS.—See **Platinotype.**

PLATINUM TETRACHLORIDE (Formula, $PtCl_4$; synonyms, *platinum perchloride, muriate of platina, platinic chloride*).—A salt prepared from metallic platinum by heating with aqua regia and evaporating. It occurs in small brownish-red masses, which, if pure, dissolve readily in water, forming a deep orange or brownish-orange solution. According to Pizzighelli the chloride of platinum sold by dealers in fifteen grain tubes is really chloroplatinic acid $PtCl_4 2HCl$. It is a fact that it certainly possesses a large percentage of free hydrochloric acid. It is used chiefly in platinum toning.

PLATINUM TONING.—As is generally known the chief substance used in photography for toning the photographic image to an agreeable color is gold. The chemical similarity between gold and platinum led to experiments being made with the latter metal to replace the former. The first published formula for a platinum toning process was given in "La Lumière" (Feb.;

* Aqua regia (a mixture of nitric and hydrochloric acid) will dissolve it slowly, forming chloroplatinic acid.
† Bloxham's "Chemistry," page 624.

1856)* by a Frenchman, M. de Carranza. He employed an acidulated solution, 1 in 2,000 of platinic chloride. This was followed by a number of other formulæ, among which must be mentioned those of Mr. Burnett.

M. P. Mercier gives† the following two rules relating to toning with platinum: First, the bath must be acid, and second it should contain a minimum quantity of a salt, for if the silver which constitutes the image is submitted to the action of an excess of salt it is transformed into chloride without any metallic deposit being formed to replace it. The reaction is represented thus:

$$Ag + PtCl_2 = AgCl + PtCl.$$

Consequently the detail of the image rapidly disappears.

If on the other hand the silver is in the presence of the minimum quantity of salt, it is replaced by a deposit of platinum and the image remains unaltered while changing color.

$$Ag + KPtCl_2 = KCl + AgCl.$$

M. Marse‡ publishes a formula for platinum toning and fixing combined. It is as follows:

A

Distilled water	100 c.c.
Platinic chloride	1.5 grammes

B

Distilled water	900 c.c.
Sodium acetate cryst.	30 grammes
Sodium hyposulphite	150 grammes

The prints are first washed, then immersed in the following mixture until the desired tone is obtained,

Solution A	10 parts
Solution B	90 parts

The most modern method of toning with platinum has, however, been devised by Lyonel Clark, C. E., who in the year 1890 published a book upon the subject.‖ His method is described in this as follows:—

The print upon the albuminized or upon plain salted paper is made in the usual way, that is to say, just slightly over-printed, as for gold toning. A negative that will give a good gold print will give a good platinum one. Matt surface paper requires stronger negatives than albumen paper. The general rule is that the pluckier the negative the richer the blacks or browns obtained. A weak negative will never give a good result.

The prints when removed from the frames may be stored away until required. They are first washed in two or three changes of water until all milkiness has disappeared.

The toning bath for black or brown tones is prepared as follows:

STOCK SOLUTION.

Potassium chloroplatinite	60 grains
Distilled water up to	2 fluid ounces

TONING BATH.

Stock solution as above	1 fluid drachm
Ordinary water up to	2 fluid ounces
Nitric acid	1 or 2 drops

In winter it is preferable to use warm water to bring the temperature to about 80°F. It must not, however, be over-heated; yellow half-tones will be the result.

It is very essential that the true chloroplatinite of potassium be used. (For method of manufacture see **Potassium Chloroplatinite.**)

With a bath, as given above, the toning commences instantly the print touches the liquid. It is, therefore, preferable to tone the prints singly. The two ounces of solution will be sufficient to tone several 12 in. × 10 in. prints. Clark thus describes his method of working:—"For holding the toning bath I employ one of the plate glass bottomed dishes as generally used for the development of bromide papers. I usually turn it upside down, so as to have the sides as low as possible, and attach three ordinary levelling screws to the upper edge, which now becomes the lower one, and with these and the aid of an ordinary spirit lever I adjust the dish. By this means the toning solution is spread over a large area on a thin but uniform layer, two ounces being according to my experience, sufficient to cover a dish measuring 18in. × 15 in. I then take the wet proof and holding it by the opposite corners, one in each hand, place one corner on the sur-

* See *British Journal of Photography*, 1858, 1859. *Photographic Times* Feb. 3, 1893.
‡ *La Nature*.
† Verages et Fixages par M. P. Mercier, translated in
‖ "Platinum Toning," by Lyonel Clark, C. E.

face of the liquid with the left hand first, and then lowering the right hand allow the print to gradually float on to the liquid in this manner, pushing in front any bubbles that may have been formed on the surface. The print may be lifted off the toning bath as often as is thought desirable, and examined by transmitted light, and if any redness is to be seen in the deep shadows replace it on the bath. When all redness has disappeared the toning is complete. The print is then lifted slowly by one end off the liquid to allow as much as possible of the liquid on the surface to run back again into the bath."

The print is then plunged into a bath containing water made slightly alkaline by carbonate of potash or soda. The use of the bath is to destroy any acid in the print carried over from the toning bath which would decompose the hyposulphite fixing bath. If only a small quantity of prints are toned the hyposulphite solution itself can be rendered alkaline, and the prints placed in it direct from the toning bath.

To get the required tone the process must be stopped at the right time. The bath given is, however, so rapid that but little control can be had over the toning. When this is desired the following bath is recomended :—

Stock solution	1 fluid drachm.
Water up to	8 fluid ounces.
Nitric acid	2 to 3 drops.

With this bath the prints may be toned as with gold solution, that is to say, immersed in the bath and moved about until the required toned is obtained, when they are removed to the weak alkaline water.

The fixing bath is the ordinary sodium hyposulphite one, with a strength of about 1 in 5 of water. A few drops of ammonia are added until it smells slightly of it. If the the parts have been toned to the full extent, that is to say, to a rich black or brown-black, they should not undergo any change in color when immersed in the fixing bath, unless it be very strong, and they are allowed to remain in it a long time. If they have only been partially toned, however, a general change in color will be the result.

After fixing for about ten minutes, the prints are thoroughly well washed and dried.

Professor Burton recommends immersing the prints before toning in a solution of common salt instead of the preliminary washing, or to add the salt directly to the toning bath, and the prints placed in directly without previous treatment.

PLUMBAGO.—See **Graphite.**

PLUMBIC ACID.—See **Lead Acetate.**

PLUMB INDICATOR.—In photographing buildings, etc., where we have a number of vertical lines, it is absolutely necessary that the sensitive surface be perfectly upright. For this purpose an arrangement termed a "plumb indicator" is sometimes used. It consists of a swinging pointer, attached to a plate (see fig. 354), which can be screwed to the swing back of the camera.

The device shows at once when the plate is vertical.

FIG. 354.

PNEUMATIC HOLDER.—A very useful little contrivance used for holding glass or other smooth plates. An elastic indiarubber ball, being exhausted of air by squeezing it, adheres firmly to the back of the plate, and can be used as a handle, allowing the plate to be coated with solution over the whole surface. (See fig. 355.)

PNEUMATIC SHUTTER.—A shutter worked by means of a small indiarubber ball at the end of a tubing of the same material. By squeezing the ball, the compressed air suffices to release the shutter. The tubing can be of considerable length, allowing the operator to stand some distance from the camera. Indeed, by this means he may include himself in a group, and take his own portrait unassisted.

POISONS.—A number of the chemicals used in the various photographic operations are poisonous either when taken internally or if absorbed through the skin or through cuts or abrasions in it. The following table of the effects and antidotes and remedies has, therefore, been compiled. In every suspicious case of poisoning a medical man should be at once sent for, the remedies given being applied pending his arrival. No time should be lost, vomiting should be caused at once by tickling the throat with a feather or by thrusting the fingers down as far as possible. Three or four teaspoonfuls of mustard in a tumbler of warm water usually acts as an emetic. If it does not act in fifteen minutes repeat it :—

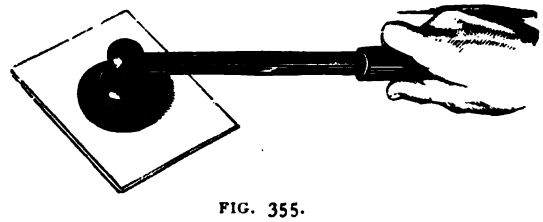


FIG. 355.

TABLES OF POISONS, WITH THEIR EFFECTS AND REMEDIES.

Poisons.	Effects.	Antidote and Remedy.
1. Acetic acid	Corrosion of windpipe, odor in breath, great pain in abdomen, perhaps convulsions, collapse and death	Large draughts of soap and water to be taken at once. The stomach pump *not* to be used. Magnesia, chalk and water, lime water, or whitewash and water may also be given,
2. Carbolic acid	Taste and odor of tar in the mouth, inside marked with whitened or black scars, dangerous fainting and collapse.	As much sweet oil and glycerine as possible, and endeavor to promote vomiting by drinking warm water, milk, or barley water. No food to be taken till inflammation has ceased.
3. Sulphuric acid, Nitric acid, Hydrochloric acid, Phosphoric acid, Fluoric acid, Tartaric acid	Hot burning pains in the throat and stomach, lips burnt and shrivelled up, excessive thirst, drink increasing the pain	Mix at once chalk and water or soap and water. No time must be lost. If none of these be handy, break down the plaster from the walls and ceiling; make into a thin paste, and give a wineglassful every two minutes, vomiting to be encouraged by drinking warm water.
4. Oxalic acid, Potassium oxalate	Hot burning sensation, vomiting, cramp, numbness, great thirst, very dangerous. One drachm smallest fatal dose known	Give lime in any form or chalk and water, but not alkalis or their carbonates; scrape the chalk or plaster from the wall, and give as in No. 3,
5. Alcohol	Drunkenness, coma, death	Stomach pump or emetic of mustard in water; keep patient continually awake and on the move, by pinching, shaking, and walking him about.
6. Ammonia	Burning sensation in mouth, throat, chest, and stomach; lips and tongue swollen, suffocation. Inhaling ammonia will cause violent irritation of the larynx	Vinegar, freely diluted with water. Acetic or any other acid diluted with large quantity of water; lemon or orange juice may be given. If unable to swallow, inhalation of acetic acid or vinegar from saturated pocket handkerchief.
7. Barium	Irritation with colic	A thimbleful of Epsom or Glauber's salts dissolved in water every few minutes. Any sulphate.
8. Benzine	Vapor acts as a narcotic; noises in the head, convulsive tremblings, convulsions, difficulty in breathing	Brandy, liquor ammonia (half a drachm in plenty of water), frequently repeated; inhalation of ammonia, alternate hot and cold douche.
9. Bromine	Acid taste, tightness about the throat	Stomach pump, egg albumen, milk.
10. Copper chloride or sulphate	Metallic tasce in mouth, constriction in throat, griping pains in abdomen, headache, giddiness, coma, death	Milk and eggs, barley water, or arrowroot, given freely, or stomach pump or emetic of warm water and mustard.
11. Gold perchloride	Caustic and corrosive	Emetics.
12. Ether	Stupefaction	Loosen everything about the chest, open doors and windows for fresh air, alternate cold and warm douche.
13. Iodine	Pain and heat in throat and stomach, with vomiting; giddiness, convulsions, death	Stomach pump or emetic of mustard and water; egg albumen and water, or arrowroot and gruel, given freely.
14. Lead acetate	Dryness in throat, metallic taste, great thirst, cramp in abdomen, cold sweats, convulsions. The sub-acetate is a still stronger poison	Sulphate of soda or magnesia, or very dilute sulphuric acid. Stomach pump, or emetic of mustard and water.
15. Mercuric chloride	Acrid taste, burning in the throat and stomach, nausea, lips and mouth white and swollen, feeble pulse and cold skin. Three grains smallest fatal dose known	White of 12 or 15 eggs beaten up in a quart of water. One wineglassful every two minutes, or milk and barley water in large draughts to ease the vomiting.
16. Potassium bichromate	Powerful poison. Acute pains in abdomen, violent vomiting, pupils dilated.	Stomach pump or emetic, carbonate of magnesia, or chalk in milk, or white of egg in milk or water. Barley water or thick gruel. Warmth to extremities and stimulents given freely.
17. Potassium cyanide	Applied to slight abrasions of the skin produces sores and ulcers	Bathe in warm water and in dilute ammonia, and afterwards poultice.
	Severe burning pain in stomach, foaming at mouth, insensibility, convulsions, stiffness of jaws and body, death.	Stomach pump or emetic. Large draughts of sulphate of iron, and water at once. Ammonia or smelling salts. Inhalation of ammonia.
	Applied to wounds and abrasions of the skin a smarting sensation is felt	Sulphate of iron should be applied immediately.
18. Potassium ferrocyanide. Potassium ferricyanide.	Insensibility, gasping, spasmodic action of jaws	Strong coffee. Dash cold water over face. Give ammonia or use smelling salts.
19. Pyrogallol	Acute burning pain in stomach	Emetics. Milk and white of eggs.
20. Silver nitrate	Powerful irritant, contraction of throat sometimes, whilst flaky matter vomited turns black on exposure to air	Copious draughts of common salt and water. Emetics of mustard or sulphate of zinc (20 grs. in water). White of egg, barley water, arrowroot, etc.

TABLES OF POISONS, WITH THEIR EFFECTS AND REMEDIED.—(*Continued.*)

Poisons.	Effects.	Antidote and Remedy.
21. Zinc, salts of.....	Corrosion of lips, vomiting, dilation of pupils, paralysis, coma, death.....	Carbonate of soda or potash dissolved in warm water, or common washing soda well diluted. Milk and eggs freely. Tannic acid or strong tea.
22. Potassium nitrate.....	Severe burning pains in abdomen, nausea, partial paralysis, convulsions, collapse	Stomach pump or emetic. White of egg and water. Olive oil or linseed tea. Patient to be wrapped in hot blankets and limbs kept warm.
23. Potash caustic.....	Heat and burning in the throat, extending to the stomach...	Give copious draught of water containing vinegar, acetic acid, citric acid, or lemon or orange juice.

POLARIZED LIGHT.—See **Polarization** under **Optics.**

POLYMERIDES.—See **Isomerism.**

PORCELAIN PAPER.—A paper having a prepared surface resembling finely-ground porcelain, and upon which very effective silver prints may be made, as the preparation, although without gloss, serves to keep the image on the surface.

The following instructions for its manufacture have been published.* Any sheet of a Saxe, Rives, or other photographic paper is coated with a warm solution of gelatine, holding in suspension sulphate of barytes, or finely-powdered kaolin. After raising the paper from this emulsion it is suspended in the air until dry, when it is immersed in a solution of alum, tannin or any other substance by which gelatine is rendered insoluble. The body of the paper is thus imbued with the gelatine, and its surface has a fine texture, the pores being all filled up.

When the paper is to be used it is salted by floating it upon a bath of chloride of ammonium and water, about four grains to the ounce of water. In this state it will keep well for many months. It is sensitized by being floated upon a bath of ammonio-nitrate of silver. An ounce of the nitrate is dissolved in sixteen ounces of water, and strong ammonia, added drop by drop, with constant stirring, until the dark precipitate at first thrown down is just redissolved. Although the way here described is that by which singurlaly fine specimens have been prepared, yet results indistinguishable from these may be produced by sensitizing on a plain nitrate of silver solution, provided that after the paper is dry it is well fumed over ammonia, by which a great degree of richness is imparted to the tone.

After removal from the printing frame the proofs are washed first in plain water and afterward in water containing a little chloride of sodium, say a grain to the ounce. Then follow toning and fixing, the prints acquiring a fine purple in the gold bath. On removal from the hyposulphite of soda it is recommended to wash the prints in three changes of warm water, followed by a prolonged immersion in cold water.

PORCELAIN PICTURE.—Very effective photograph pictures can be made upon porcelain by the collodio-chloride emulsion process (*q.v.*), or by the burnt-in enamel method. Chloride plates are now supplied with a milky or semi-translucent glass as the support, and much resemble porcelain when finished.

POROSITY.—A term used to denote the fact that in all matter the constituent particles are not completely contiguous to one another, but separated by intervening spaces or pores. The opposite term to density.

POROTYPE.—A German method of copying engravings, depending on the fact that those parts of the prints occupied by the ink are non-porous. A gas which acts upon a certain chemical agent, and either bleaches or discolors it, is permitted to penetrate a copper-plate engraving, or wood-cut where possible, and coming into contact with suitably prepared paper alters it, a copy of the engraving being thus produced.

PORTABLE APPARATUS.—A term given to light, compact photograph apparatus, suitable for tourists or out-door photography.

PORTRAIT LENS.—See **Lens.**

PORTRAIT MOUNT.—See **Mount.**

PORTRAIT STUDIO.—See **Studio.**

PORTRAITURE.—Portrait photography is one of the most difficult branches of the art, and requires considerable experience and artistic culture. Amateur photographers, as a rule,

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fail in their attempt at this class of work owing to want of experience, and also to want of suitable appliances. Although by judicious management, fairly good portraits can be made in the open air, or in a well-lighted room, yet the best results are only obtainable in a properly constructed portrait studio. The advantage of the glass house or studio lies, not only in the fact that a large quantity of light is admitted, but principally in the additional arrangement by means of which the quality and quantity of the light can be regulated and adjusted at the will of the operator. An artist could not easily depict a round ball without suitable shading. A portrait taken in the open usually has this defect, namely the lighting is the same all over the face, causing it to appear flat and pasty in the picture. In the studio, however, the light is thrown more on some portions of the face than on others, so as to give a delicate shading and roundness to the image.

Considerable artistic skill and ability is required in posing the sitter in a natural and pleasing position. There are few photographs in which the sitter does not appear to be aware that he is being photographed, and a most constrained and unnatural effect is the result.

Fairly good portraits may often be made in a well-lighted room having large windows preferably facing the N.N.W. or N.E. To avoid too black and white results, a reflector or white screen should be used to light up the side of sitter away from the window.

With regard to the lens most suitable for portrait work, this will be found treated upon under **Lens.**

Rapid plates are the best for this purpose, as the shorter the exposure the less chance the sitter has to move. For very restless subjects a head-rest should be used, but only when absolutely necessary.

Avoid elaborate backgrounds and accessories. With a plain or graduated background the best effects are obtainable. If accessories or scenic backgrounds are to be used they should be in harmony with the subject. No further information upon the subject of lighting and posing can be given, experience and natural ability are required. Several books (notably those by H. P. Robinson) have been published on the subject, which the student would do well to follow.

Artificial light is now being employed in portrait photography. Electric light, magnesium light, flashlight and gaslight have all been employed. Electric light is perhaps the most suitable, although the most difficult and expensive to obtain.

The light is usually fixed in the center of a large parabolic reflector, and thus thrown down on the sitter; various other reflectors are used to light up the darker parts and prevent too great contrasts. The sitter's eyes must be carefully guarded from the light, otherwise an unnatural expression will be given.

POSITIVE.—The image of an object in which the lights and shades are represented as seen in nature. It is the opposite to a negative.

Positives may be obtained directly in the camera, or from the negative, by a great variety of processes.

In the Daguerreotype and ferrotype processes the images made in the camera appear as positives owing to the dark color of the support.

If a dry plate be exposed for some length of time more than required to produce a negative, a reversal of the image takes place and a positive is the result, usually very defective, however.

Colonel Waterhouse has recently discovered a most important method of obtaining direct photographic positives upon ordinary silver bromide dry plates. By the addition of minute quantities of certain derivatives of carbamide (urea) to the developer a reversed action is obtained, and a positive produced instead of a negative. The process has not as yet been perfected, although, from the results of experiments, there is no doubt that it is only a matter of time and careful study.

POSITIVE ABERRATION.—See **Aberration.**

POTASH.—A term applied to the hydrate of potash KHO, but also used to denote potassium oxide, and formerly also carbonate of potash. (See **Potassium Hydoxide.**)

POTASSIO-FERRIC OXALATE (Formula, $Fe_2(C_2O_4)_3+3K_2C_2O_4$).—Occurs in tabular green crystals, which gradually turn brown on exposure to light. It crystallizes out of used-up ferrous oxalate developers, and mixed with potassium oxalate forms old platinotype hot-bath developers. It is employed in some of the blue or cyanotype printing processes owing to its property of decomposing by the action of light and in Belitzki's formula for reducing.

POTASSIO-FERROUS OXALATE ($FeC_2O_4,K_2C_2O_4$).—A reddish-orange colored liquid obtained by mixing together solutions of ferrous-sulphate and potassium oxalate, and contains potassio-ferrous-oxalate mixed with potassium sulphate. It is a powerful deoxidizing agent, and is for this reason used as a developer in the dry-plate process. (See **Ferrous Oxalate.**)

POTASSIUM (Symbol, K; atomic weight, 39·1).—A monad metallic element discovered by Davy. It is widely diffused through the vegetable, mineral, and animal kingdoms. It is usually present combined with inorganic or organic acids, and when its organic salts are burnt they are

resolved into carbonate, from which all the other salts of potassium can be prepared. It is the lightest of all metals save lithium, having a sp. gr. of ·865. It has a light bluish color; at 0°C. it is brittle and crystalline, at 15°C. it can be cut without difficulty with a knife, at 62·5°C. it is fluid, and at red heat it distils, yielding a fine green vapor. If thrown upon water the metal decomposes it with great violence, hydrate of potassium being formed, while the hydrogen gas, whieh escapes immediately, takes fire, burning with a red color. To preserve it in the metallic state it must be immersed in rock oil.

To detect potassium salts, moisten with a drop of hydrochloric acid, and hold on a platinum wire in a Bunsen flame. It colors it violet. Solutions containing potassium give the following reactions: A yellow crystalline precipitate with platinic chloride or with picric acid if the solution be sufficiently strong; a white gelatinous precipitate with silico-fluoric acid.

POTASSIUM ALUMINIUM SULPHATE (Formula, $Al_2K_2(SO_4)_4\ 12H_2O$; synonym, *potash alum*).—Found native in Italy and in the South of France. It occurs in transparent irregular crystals, or in a finely powdered state, soluble in ten times its own weight of cold water. It possesses the property of hardening and rendering gelatine insoluble, and is for this reason much employed in photography. (See **Alum.**)

POTASSIUM ANHYDROCHROMATE. See **Potassium Dichromate.**

POTASSIUM ANTIMONIATE (Formula, $2KSoO_3{\cdot}5H_2O$).—A granular powder soluble in warm water, employed as a test for sodium, with which it forms a heavy crystalline precipitate of sodium antimoniate, very sparingly soluble in water. The solution for this purpose must be either neutral or alkaline, as acids will decompose it.

POTASSIUM BICARBONATE (Formula, $KHCO_3$; synonym, *hydro-potassium carbonate*) Often sold as potassium carbonate. It is, however, far less soluble in water, and less alkaline.

POTASSIUM BICHROMATE.—See **Potassium Dichromate.**

POTASSIUM BROMIDE.— (Formula, KBr; molecular weight, 119; synonym, *bromide of potash*).—Prepared in white cubical crystals by the action of bromide on potassium. The usual method of manufacture is by acting on bromide of iron with carbonate of potash, or by adding bromine to caustic potash and heating the product or mixture of potassium bromide and bromate of potash to a red heat until the oxygen is driven off from the latter salt. It crystallizes in anhydrous cubes, which are very soluble in water (100 in 75), sparingly soluble in alcohol. It is used in photography in the manufacture of bromide emulsions not containing alcohol. Its reaction upon silver nitrate is thus expressed, $AgNO_3 + KBr = KNO_6 + AgBr$, potassium nitrate and silver bromide being formed. It is also used as a restrainer in the so-called alkaline developing process, its action being apparently to form a more stable compound with the silver bromide less easily decomposed by the developer.

POTASSIUM CARBONATE (Formula, CKO_3; molecular weight, 136; synonyms, *sub-carbonate of potash, pearlash, salt of tartar, salt of wormwood potash*). When the ashes of plants are treated with water the salts of potassium are dissolved, those of calcium and magnesium being left. On separating the aqueous solution, and evaporating it to a certain point, much of the potassium sulphate is deposited, it being less soluble. The carbonate remains in the solution, which is evaporated to dryness, when the carbonate is left mixed with potassium chloride and some sulphate. This is largely imported into this country and sold as *potashes*. After undergoing a slight purification process it is sold under the name of pearlash, but is far from being the pure carbonate of potash. A somewhat pure carbonate can be obtained quite free from sulphate, and containing but a trace of chloride.

Potassium carbonate occurs as a white deliquescent powder, and very soluble in water, but insoluble in alcohol. It is used in photography in developing, and also in the preparation of other potassium salts. It has also been used to free alcohol from the water contained in it.

POTASSIUM CHLORATE (Formula, $KClO_3$; synonym, *chlorate of potassium*).—Forms tabular crystals very soluble in boiling, and moderately soluble in cold water. It is used in the platinotype process for increasing the depth of contrast. This it accomplishes by converting a portion of the potassium chloro-platinite into potassium chloro-platinate; this latter is then unacted upon by the ferrous oxalate.

POTASSIUM CHLORIDE (Formula, KCl).—Occurs native as sylvite, and is also obtained from sea-water, and from the refuse of the manufacture of sugar from beetroot. It crystallizes in cubes, is very soluble in water, and almost insoluble in alcohol. The addition of potassium chloride to the ferrous oxalate developer has been recommended as a means of obtaining sepia tones with bromide paper prints.

POTASSIUM CHLORO-PLATINITE (Formula, K_2PtCl_4)—Takes the form of reddish deliquescent crystals, very soluble in water, but slightly in alcohol. It should dissolve in water

without any residue and give a neutral solution. Messrs. Pizzighelli and Hübl in their work on the platinotype process give the following instructions for its manufacture: "Take 50 grammes of platinum chloride (chloroplatinic acid), dissolve in 100 c.c. of pure water, and filter if necessary; then heat to 100 degrees C. in a water bath, and pass through it a strong stream of washed sulphurous acid gas. After a while the yellow liquid will begin to assume the characteristic red color of the platinous chloride. The liquid has then to be tested from time to time to watch its progress. A little is taken on the end of a glass rod and mixed with a little ammonium chloride on a watch glass; the presence of any unreduced or platinic chloride is shown by the formation of an insoluble yellow precipitate of chloroplatinate of ammonia. The quantity of this precipitate that is formed should be noted, as one can judge from this of the amount of reduction that is going on. When the precipitate begins to form but slightly, the stream of gas should be checked so as to have the operation well under control, and as soon as the liquid ceases to give a precipitate the gas stopped completely. The reason for this is that if allowed to continue the gas would commence to attack the platinous chloride form, and further convert it to a platinous sulphide, a salt not reducible by ferrous salts. On the other hand, if the action be stopped too soon, platinic chloride will be left, and in the further operations would be thrown down as an insoluble salt. Hence care is necessary in the above operations.

"The solution that is obtained consists of a mixture of platinous chloride, sulphuric and hydrochloric acids. To convert this into the double salt it should, after cooling, be poured into a porcelain basin, and a hot solution containing 25 grammes of chloride of potassium in 50 c.c. of water well mixed with it by stirring. The chloroplatinite then separates in the form of a crystalline deposit and is collected on a filter, the mother liquor being drained off; it is then washed with a little water, and then a little alcohol, until the last washing gives no acid reaction.

"The powder is now spread out on filtering paper and left to dry in a dark room, as the salt when moistened with alcohol is reduced by the action of light. Salt thus prepared is perfectly pure and can be used at once. Seventy-four or seventy-five grammes of the double salt should be obtained from each 100 grammes of platinic chloride, this being about 93 per cent. of the theoretical quantity. No effort need be made to obtain from the mother liquor a still further quantity of potassium chloroplatinite."

Potassium chloroplatinite is employed in photography in the platinotype process, owing to the fact that ferrous oxalate reduces it to metallic platinum. The action is thus expressed:

$$6FeC_2O_4 + 3K_2PtCl_4 = 2Fe_2(C_2O_4)_3 + Fe_2Cl_6 \times 6KCl + 3Pt.$$

POTASSIUM CITRATE (Formula, $K_3H_5C_6O_7$; synonym, *citrate of potash*).—A white semi-crystalline salt, very deliquescent, soluble in alcohol and insoluble in water. It is used as a restrainer in alkaline development, as a preservative of ready sensitized paper, and is generally added to gelatino-citro-chloride emulsions.

POTASSIUM CYANIDE (Formula, KCN; molecular weight, 65; synonyms, *cyanide, cyanide of potash*).—Prepared by fusing in an iron crucible a mixture of eight parts of well-dried potassium ferro-cyanide with three parts of potassium carbonate.

When effervescence has ceased and the iron which separates has settled down, the clear liquid is poured off on to slabs. On cooling it solidifies, and is broken up into the irregular masses met with in commerce.

The purest form, however, is made by passing vapor of hydro-cyanic acid into a solution of potash in absolute alcohol, when the cyanide is deposited in small octahedral crystals.

Commercial potassium cyanide occurs in white lumps, containing about 60 per cent. of cyanide, the rest being cyanate and carbonate. These impurities only serve to lessen its strength and have no injurious effect.

It is extremely deliquescent, it being soluble in its own weight of water. It is insoluble in alcohol. It is one of the most dangerous of poisons. When cyanide is employed always keep handy an antidote consisting of a mixture of ferrous sulphate and ferric chloride, made as follows: Dissolve 20 grains of potassium carbonate in 2 ounces of water, and into this pour 2 drachms of the pharmaceutical tincture of perchloride of iron (*Tinctura ferri perchloridi*), and half fill with water. When using dissolve 10 grains ferrous sulphate in a little water, add this to the other mixture, shake up, and drink off at once. In half an hour take an emetic. If treated with an acid it gives off hydro-cyanide, or prussic acid gas, which, when inhaled, causes insensibility, and has been known to cause death. It should, therefore, be used under all circumstances with extreme caution.

It has several uses in photography, principally as a fixing agent in the wet collodion process, on account of its property of dissolving silver chloride and iodide. It cannot conveniently be used as a fixing agent for dry plates, owing to its disintegrating action upon gelatine. It is not, however, superior to hyposulphite of soda, and is very dangerous. It is further employed for reducing the density of negatives.

POTASSIUM DICHROMATE (Formula, $K_2Cr_2O_7$; molecular weight, 293; synonyms, *bichromate of potash, potassium anhydrochromate, red chromate of potash, acid chromate of potash.*)—The

chrome iron ore is first heated to redness and thrown into water; it can then be easily ground to a fine powder, which is mixed with potassium carbonate and a little chalk added. This is strongly heated in a current of air, constantly stirring the mass. On afterwards heating the mass with water a yellow solution of potassium chromate is obtained, which is then drawn off from the insoluble residues and mixed with a slight excess of nitric acid. The solution when evaporated deposits beautiful red tabular crystals of potassium dichromate. When purchasing see that these crystals are well formed and uniform throughout, not having yellow edges. It is soluble in about ten parts of water or alcohol at 60°F. Taken internally it is an irritant poison (see poisons) If absorbed by the skin or allowed to enter cuts or abrasions, ulcers will form (see **Bichromate Disease**.)

Potassium dichromate is of great commercial importance. In photography it is also largely employed. It has been discovered that when in contact with gelatine or other organic matter it is decomposed by light, and renders the gelatine or other organic soluble body insoluble, and incapable of absorbing water.* This important property is the foundation of a very large number of photo-mechanical printing processes, and also of several other processes, such as the carbon process, powder process, etc. It is stated that papers prepared with potassium dichromate and silver nitrate have given images varying in color from red to green and blue.

Potassium dichromate is not a true acid salt, for it contains no hydrogen. It is sometimes termed anhydro-chromate, and written $K_2Cr\ O_4 . Cr\ O_3$.

Potassium Trichromate (Formula $K\ O.3CrO_3$) has been obtained in red crystals by the addition of nitric acid to the dichromate.

POTASSIUM FERRIDCYANIDE (Formula $K_4Fe_2\ (C_6N_6)_2$; molecular weight, 658; synonyms, *potassium ferricyanide, red prussiate of potash*).—Prepared by the action of chlorine gas upon potassium ferrocyanide. The gas is passed into the solution of ferrocyanide until a little of the solution tested with ferric-chloride no longer gives a blue precipitate. The resulting solution is then crystallized. Potassium ferricyanide takes the form of deep red crystals, soluble in water but sparingly in alcohol. It is used with hypo in reducing the density of gelatine negatives and in the cyanotype printing process.

POTASSIUM FERROCYANIDE (Formula, $KFeC_6N_63H_2O$; molecular weight, 422; synonym, *yellow prussiate of potash*).—Prepared by heating nitrogenous matter, such as hoofs, horns, etc., with pearlash and iron filings, the resulting mass being dissolved in water and evaporated. It crystallizes in large yellow powdered pyramids soluble in twice the weight of boiling, and four times the weight of cold water. It is insoluble in alcohol. An aqueous solution turns a dark yellow if exposed for any length of time to the air, oxygen being absorbed, and small quantities of potassium ferricyanide produced. It is non-poisonous alone, but acids will change it into a very violent poison. The addition of a small quantity to the carbonate developer has been recommended by Professor Newton. It is also used in certain blue processes and as a test for ferric salts on account of its property of changing such salts to a deep blue color, preventing fog, and giving a clear black image, and brilliant and sparkling negative.

POTASSIUM FLUORIDE (Formula, KF).—Prepared by neutralizing hydrogen fluoride with potassium carbonate. Formerly used in photography in the iodizing solution for waxed papers. It corrodes glass, and must therefore be kept in a gutta-percha or platinum vessel.

POTASSIUM HYDRATE.—See **Potassium Hydroxide.**

POTASSIUM HYDROXIDE (Formula, KOH; synonyms, *potassium hydrate, caustic potash*). —Obtained by adding slaked lime to a boiling solution of the potassium carbonate in not less than 12 parts of water, when calcium carbonate is deposited at the bottom of the vessel, leaving potassium hydrate in the clear solution. It is then evaporated, the potassium hydrate remaining as a clear oily liquid, which in cooling solidifies to a white mass. This is the fused potash of commerce. It is generally, however, cast into cylindrical shaped sticks for greater convenience in using. It is very deliquescent, absorbing carbon dioxide from the air. It should, therefore, be preserved in well-stoppered bottles. It is employed in alkaline development.

POTASSIUM IODIDE (Formula, KI; molecular weight, 166; synonym, *iodide of potash*).—Prepared by adding small quantities of iodine to a solution of potash until it has a slightly brownish color. This is then evaporated to dryness, and the residue mixed with one-tenth of its weight of powdered charcoal, and thrown into a red-hot iron crucible, and fused to decompose any iodate of potash that may be formed. The mass obtained is dissolved in hot water, filtered, evaporated until a thin film makes its appearance on the surface, and set aside to crystallize. It crystallizes both in cubes and prisms, which are anhydrous and extremely soluble in water and slightly in alcohol.

Commercial iodide of potassium often contains carbonate, sulphate and iodate as impurities. It can be purified by re-crystallizing it from spirit, or by dissolving in alcohol of .805, as in this the impurities mentioned are insoluble.

*According to Dr. Eder, the insoluble gelatine is an unstable compound of unaltered gelatine and chromous chromate, potassium being simultaneously formed.

Iodide of potassium was formerly much used for iodizing papers for the calotype and waxed paper processes, and also for collodion. For the latter, however, it is much inferior to the other iodides. Its chief use at present is in the manufacture of some kinds of gelatine emulsions to form silver iodide. Its action may be stated thus—

$$KI + AgNO_3 = AgI + KNO_3$$

POTASSIUM METABISULPHITE (Formula, $K_2S_2O_5$; synonym, *metabisulphite of potash*).—Obtained in clear transparent crystals, having an odor of sulphur dioxide. It is soluble in three times its weight of water, but insoluble in alcohol. If treated with an excess of hydrochloric acid, it should give but a very faint precipitate with barium chloride.

It has recently been recommended for the same purpose as served by sodium sulphite, *i.e.*, as a preservative of solutions of pyrogallol, quinol, eikonogen, etc.

POTASSIUM NITRATE (Formula, KNO_3; molecular weight, 101; synonyms, *nitrate of potash, nitre, saltpetre*).—Found in the soil of India and other hot countries during the dry season. It can also be made artificially by decomposing sodium nitrate with potassium chloride. It occurs either in white crystalline masses or prismatic needles soluble in about half its weight of boiling, and in four times its weight of cold water. If quite pure it should not be precipitated either by silver nitrate or barium nitrate, proving the absence of both chlorides and sulphates.

Potassium nitrate is used in photography for the manufacture of nitric acid and of pyroxyline; for the latter purpose it should be as pure as possible, and entirely free from any chlorides.

POTASSIUM NITRITE.—(Formula, KNO_2; molecular weight, 85).—Prepared by fusing potassium nitrate in a fireclay crucible, and heating to redness, when oxygen is given off, and it slowly becomes converted into potassium nitrite. It is a very deliquescent salt.

POTASSIUM OXALATE.—(Formula, $K_2C_2O_4$; molecular weight, 164; synonym, *neutral oxalate of potash*).—Prepared by neutralizing oxalic acid with caustic potash or potassium carbonate. Obtained in white crystalline masses or in powder. As it is always used in the liquid state, the following simple method for preparing it in that form will be found useful: Dissolve 26 ounces of potassium carbonate in 60 ounces of water, and very slowly add about 18 or 19 ounces of oxalic acid till, after boiling, the solution is neutral to test paper. Filter and add water until the whole measures 128 ounces, when a 25 per cent. solution is then obtained.

Potassium oxalate is soluble in about three parts its weight of water. It sometimes contains sodium oxalate, which may be detected by moistening a little of the salt with strong sulphuric acid, evaporating in an open dish to complete dryness, then gently igniting until fumes cease to be evolved, and again moistening the cold residue with hydrochloric acid. By dipping a platinum wire in the mixture and holding it in a flame of a Bunsen burner the colorless flame will turn yellow if sodium be present.

In purchasing this oxalate from drug stores be sure that potassium binoxalate or salt of sorrel (KHC_2O_4) is not substituted for it. This can be distinguished from potassium oxalate by its inferior solubility (1 in 40). In the event of a mistake having been made, salt of sorrel can be converted into the photographically useful oxalate by neutralizing it with potassium carbonate, thus :—$2KHC_2O_4 + K_2CO_3 = 2K_2C_2O_4 + H_2O + CO_2$."*

Potassium oxalate is much used in photography as a solvent of ferrous oxalate for use as a developer for silver bromide and silver chloride plates and papers, and also as a developer in the platinotype process.

POTASSIUM OXIDE.—Potassium forms three oxides—(1) Protoxide, K_2O; (2) dioxide, K_2O_2; and (3) tetroxide K_2O_4.

POTASSIUM PERMANGANATE (Formula, $KMnO_4$; molecular weight, 158; synonym, *permanganate of potash*).—Prepared by mixing together four parts of finely powdered manganese dioxide and 3½ parts of potassium chlorate and five parts potassium hydrate dissolved in a little water. The pasty mass formed is dried and heated to dull redness in an earthen crucible. The potassium chlorate gives the oxygen required. The cold mass is afterwards treated with cold water, when the potassium manganate is dissolved, forming a dark green solution. This is diluted with water, and a stream of carbonic acid gas passed through it until no further change of color is observable. The precipitated manganese dioxide is permitted to settle, and the clear red solution decanted and evaporated to a small bulk. On cooling, it deposits prismatic crystals of permanganate, which are red by transmitted light, but reflect a dark green color. The potassium carbonate remains in the solution.

Permanganate of potash is soluble in 16 times its weight of cold water, but insoluble in alcohol. It is used in photography for intensifying wet plate collodion negatives, the silver image being first converted into silver iodide. It is further employed as a test for hypo, and as an eliminator,† and to improve old wet collodion silver baths by oxidizing the organic matter in them. It is also a remarkable disinfectant, and, sold under the name of "Condy's Fluid," is largely used for deodorizing solid or liquid substances.

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*C J. Leaper. †Photo Times, p 58, Vol. XXIV.

POTASSIUM SALTS, TESTS FOR.—Platinic chloride gives a yellow crystalline precipitate, and the same with picric acid if the solution be sufficiently concentrated.

POTASSIUM SULPHIDE (Formula K_2S_3; synonyms, *potassium trisulphide, sulphide of potash, liver of sulphur*).—A liver-colored, deliquescent, amorphous mass, soluble in water, obtained by heating together sulphur and carbonate of potash. It is used in photography to precipitate black silver sulphide from old fixing solutions. The latter must not contain any alum, however, otherwise it would be precipitated with the silver sulphide.

POTASSIUM SULPHOCYANATE (Formula, KCNS; molecular weight, 97; synonyms, *potassium thiocyanate, potassium sulphocyanide, sulphocyanide of potash*).—Forms colorless crystals easily soluble in water and alcohol. It is used in the toning processes, and has been recommended as a developer in the carbon process owing to its property of dissolving gelatine. It is a highly poisonous salt, and should be used with extreme caution.

POTASSIUM THIOCYANATE.—See **Potassium Sulphocyanate.**

POTASSIUM TRISULPHIDE.—See **Potassium Sulphide.**

POWDER PROCESS, also known as the "dusting on" process.—A method of producing photographic images in any color upon paper, glass, metal, or other supports. The principle of the process is this: An organic tacky substance is sensitized with potassium dichromate, and exposed under a reversed positive to the action of light. All those parts acted upon become hard, the stickiness disappearing according to the strength of the light action, while those parts protected by the darker parts of the positive retain their adhesiveness If a colored powder be dusted over it will be understood that it will adhere to the sticky parts only, forming a visible image, the same being a reproduction of the positive printed from. The process is very useful for the production of lantern slides and transparencies, or for the reproduction of negatives. Any of the following formulæ may be employed for the manufacture of the organic substance :—

SOLUTION A.

Gum arabic	25 grammes
Grape sugar	60 grammes
Purified honey	15 grammes
Alcohol 40 deg	15 c.c.
Water	60 c.c.

SOLUTION B.

Saturated solution of ammonium dichromate.

Two solutions to be mixed together before using in proportions 15 A, 25 B, 50 water.

WOODBURY'S FORMULA.

Gum arabic	60 grains
Glucose	45 grains
Glycerine	10 minims
Potassium dichromate	30 grains
Distilled water	2 ounces

OBERNETTER PROCESS.

Dextrine	60 grains
White sugar	75 grains
Ammonium dichromate	30 grains
Glycerine	2 to 8 minims
Distilled water	3 ounces

The gum is first dissolved and the remainder of the ingredients added. It may be necessary to warm the solution in a hot water bath to dissolve it. It is then filtered through flannel or clean muslin, and preserved for use in well-stoppered bottles. With this solution clear glass plates are coated and dried by a gentle heat over a small spirit lamp. The plate while still warm is exposed under a reversed positive* for from 2 to 5 minutes in sunlight, and from 10 to 20 minutes in diffused light. The image is then but slightly visible. On removing from the printing frame the plate is laid in the air (protected from light) for a few minutes to absorb a little moisture from it. The next process is the "dusting on." If the image is required to be black, fine Siberian graphite is spread over it with a soft flat brush. This will adhere to the parts unaffected by light, giving an image of the positive. Any colored fine powder may be used, giving images in various colors. When fully developed the excess of powder is dusted off and the film coated with collodion. After this it is well washed to remove the unaltered gum and dichromate salt. The film may, if desired, be detached from the plate and used for enamels, ivory, wood, textile fabrics, opals, etc.

By the above process it will be seen that to obtain a positive we require a positive. Mr. G. W. Wood has recently patented a method of producing positives from negatives by this method. The principle of the process consists in using a black or dark-colored material, such as ebonite,

* Reversed as regards right and left.

vulcanite, ferrotype plates, or glass coated with a black or dark-colored varnish as the support or ground, and dusting on a suitable lustrous substance, such as white, gold or other light-colored bronze powders or aluminium, magnesium, zinc, tin, silver, or other suitable metal or alloy reduced to powder.

It is obvious that if the ground be dark and the bronze powder be light we get the opposite effect to that obtained with a light ground or support and a dark-colored powder. By this means we are therefore able to get a positive (viewed by reflected light only) from a negative.

PRECIPITATION.—Solid matter thrown down from a state of solution by the action of heat, light or chemical reagent, is termed a precipitate. If one solution be added to another to form a precipitate the former is termed the precipitant.

PRESCRIPTION.—A medical recipe. The following explanation of the different signs used in writing prescriptions may often be found useful:

Quantity.	*Sign.*	*Quantity.*	*Sign.*
½ grain	½ gr.	1 drachm	ʒi or ʒj.
1 grain	gr. j or gr. i.	1½ drachm	ʒiss.
1½ grain	gr. iss.	2 drachms	ʒii or ʒij.
2 grains	gr. ii or gr. ij.	3 drachms	ʒiii or ʒiij.
2½ grains	gr. iiss.	3½ drachms	ʒiiiss.
4 grains	gr. iv.	7½ drachms	ʒviiss.
8 grains	gr. viii or gr. viij.	½ ounce	℥ss.
½ scruple	℈ss.	1 ounce	℥i or ℥j.
1 scruple	℈i or ℈j.	1½ ounce	℥iss.
1½ scruple	℈iss.	½ pint	Oss.
2 scruples	℈ii or ℈ij.	1 pint	O.

PRESERVATIVE.—An erroneous term applied in the dry collodion process to substances used to give density and transparency to the negative and to cause the film to adhere. The principal requirements in a preservative are thus stated by Abney: First, it must be an iodine or bromine absorbent, for without this quality the film manifestly might be insensitive; secondly, it must be capable of filling up the minutest pores of the collodion, so that on re-wetting after drying it may give access to the developing solution; and thirdly, it must act as a protective varnish against the atmospheric influences.

The action of the preservative is chiefly to absorb the iodine and bromine liberated by the action of light from the silver iodide and bromide present in the film.

The following are a few of the best known preservative solutions:

No. 1.

Tannin, pure	10 to 15 grains
Water (distilled)	1 ounce

No. 2.

Gum arabic	90 grains
Sugar candy	20 grains
Water (distilled)	5½ ounces

No. 3.

Coffee (Mocha)	½ ounce
White sugar	90 grains
Distilled water (boiling)	5½ ounces

No. 4—Sol. A.

Gum arabic	20 grains
Sugar candy	5 grains
Water	6 drachms

Sol. B.

Gallic acid	3 grains
Water	2 drachms

Sol. B is prepared by heat, and mixed with sol. A. (See also **Collodion Process, Dry.**)

Preservative for Sensitized Paper.—It is well known that albumen paper, sensitized with silver, will not keep for any length of time. Various preservatives have been recommended to improve this. The commonest consists of an addition of citric acid to the silver bath. The sensitizing bath then reads:—

Silver nitrate	60 grains
Citric acid	25 grains
Water	1 ounces

Paper thus prepared will keep for months. Debenham advocates the addition of 10 drops of pure perchloric acid to each fluid ounce of the silver bath instead of the citric acid. Commercial sensitized paper is usually silvered with an ordinary bath, and the paper afterwards floated on a preservative solution of—

Citric acid	1 ounce
Tartaric acid	1 ounce
Water	30 ounces

PRESSURE FRAME.—A printing frame adapted for printing from the negative on paper, glass and other substances, so called because the back portion is so arranged that it presses the paper and other material well into contact with the negative. If this is not the case the image will appear blurred in parts, and will be likely to shift during the printing operations.

PRIMULINE PROCESS.—A recent process invented by Messrs. Green, Cross and Bevan. It is better known, however, as the "Diazotype process." The following description of it is partly taken from a lecture given by the inventors*:—

This process in reality consists of a new application of a group of colored compounds, of which the dyestuff known as primuline is the typical representative. Primuline is the sodium sulphonate of a complex amido base, which is obtained by heating paratoluidine with sulphur. Its formation is preceded by that of dehydrothiotoluidine, a body which appears to be an amido-benzenyl-amidothiocresol, and the primuline base appears to result from a further condensation of this compound, and to differ from it in the same way that dehydrothiotoluidine itself differs from paratoluidine. This view is expressed in the formula for primuline proposed by Gattermann.

Homologues of primuline closely similar to it in properties are similarly obtained from metaxylidine and pseudo-cumidine.

In printing upon textile fabrics the material is first dyed with a hot solution of primuline, to which some common salt may be added. About fifteen to thirty grains of primuline are added to about a gallon of hot water. In this solution the fabric acquires a primrose-yellow color. It is then washed in cold water, and afterwards diazotized by immersion for about half a minute in a cold solution of sodium nitrite ¼ per cent., which has been sharply acidified with hydrochloric, sulphuric, or other acid. The material is now washed in cold water and stretched out on a level white surface, and exposed to light beneath the object of which it is required to produce a positive reproduction. It is, of course, possible to print from ordinary photographic positives or from natural objects or from any painted, printed, or photographed design or picture upon any sufficiently transparent material. Either sunlight or an artificial light of sufficient intensity may be employed, the time of exposure, of course, varying with the intensity of the light. In printing by daylight it varies from half a minute in bright sunshine to half an hour or so in very dull weather.

When the decomposition of the diazo compound in the high lights of the picture is complete (which can be easily ascertained by means of a test slip exposed simultaneously and touched with a solution of β-naphthol, at intervals) these portions will be found to have changed from an orange to a pale yellow. The material is now either passed into the developing bath at once or is kept in the dark until it is convenient to develop the image. The developing bath consist of a weak solution (about ¼ per cent.) of a suitable phenol or amine, depending upon the color in which the design is to be produced. The following phenols and amines, amongst others, have been found to give good results:—

For Red, an alkaline solution of β-naphthol.

For Maroon, an alkaline solution of a β-naphthol disulphonic acid.

For Yellow, an alkaline solution of phenol.

For Orange, an alkaline solution of resorcin.

For Brown, a slightly alkaline solution of pyrogallol, or a solution of phenylenediamine-hydrochloride.

For Purple, a solution of α-naphthylamine-hydrochloride.

For Blue, a slightly acid solution of amido-β-naphthol-βsulphonate of sodium (eikonogen).

If the design is desired to be produced in two or more colors the respective developers suitably thickened with starch, if necessary, may be applied locally by means of a pad or brush. After development, which with cotton is complete in less than half a minute, the material is washed, and the picture requires no further fixing. In the case of the purple and blue developers it is necessary to wash the material finally in a very weak solution of tartaric acid It is sometimes advantageous to heat for a few seconds in a hot soap bath.

Velveteen, linen, silk, wool, and other fabrics may be treated in the same manner except that in the case of wool and silk a longer exposure to light is necessary, and the immersion in the nitric and developing baths must also be more prolonged. The maroon and blue developers are not suitable for silk and wool.

Architectural and engineering drawings can be copied with clearness and accuracy upon paper or calico which has been dyed with primuline diazotized and dried. The diazo-paper for this purpose can be kept in the dark for some time without undergoing decomposition. The copy is developed by brushing over the surface a solution of β-naphthol or α-napthylamine.

Transparent photograph pictures can be produced upon glass by coating with a film of gelatine containing primuline, then diazotizing with nitrous acid, printing, say, from a carbon or

* From the "Journal of the Society of Chemical Industry," 29th November, 1890.

a silver positive, and developing as before. In all the above application the primuline may be replaced by the higher homologues, already mentioned, and for producing designs upon silk dehydrothiotoluidine sulphonic acid, and its homologues may be employed, which are equally sensitive to light.

The above described process is probably the first which has been devised in which derivatives of the aromatic hydrocarbons are employed for the production of a *positive* image capable of development in color.

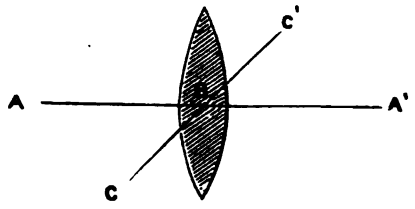


FIG. 356.

A process was recently invented and patented by A. Feer,* based upon the fact that when the diazo compounds are treated with an alkaline bisulphite they are converted into the diazo-sulphonates.† These compounds are sensitive to light, the action of which is to set free the diazo group from its combination, but they do not react with phenols and amines as do the diazo compounds. The mixture of a diazo sulphonate with the latter is unattended by any color reaction, but on exposure to light, the diazo group being set free in presence of a phenol, the development of an azo color takes place *pari passu*. The photographic surface is a mixture of a diazo-sulphonate with the alkali compound of a phenol applied to any suitable material. On exposure to light under a transparency, development of color takes place in proportion to the quantity of light transmitted, giving therefore, a reversed reproduction or negative picture. When printed the unattached mixture is dissolved away by copious washing, leaving the picture already developed in the azo-color permanently fixed upon the fabric or material.

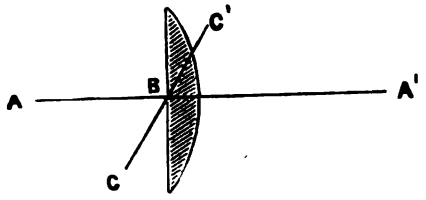


FIG. 357.

It will be seen that the latter process is in point of simplicity inferior to the primuline process, nor are the results superior. The primuline process can be adapted to a very large number of uses. No technical knowledge is required. The description of the process already given will be found sufficient. Most delicate pictures can be printed upon all kinds of materials, either from photographic positives or from natural subjects, such as fern leaves, etc. It also bids fair to supersede the old blue process for the reproduction of maps, drawings, etc. The images obtained will resist the action of hot soap and water. They are also exceedingly fast to light.

PRINCIPAL AXIS.—The right line which joins the centers of curvature of the spherical surfaces of a lens. If one surface be plane, however, the principal axis will pass through the center of curvature of the spherical and perpendicular to the plane surface.

In Figs. 356 and 357 A A′ are the centers of curvature, or, in other words, the points from which the axis of the circles forming the spherical surfaces are calculated. A B A′ is the principal axis. A straight line passing through the optical center and making an angle with the principal axis is termed the secondary axis C C′.

PRINCIPAL FOCUS.—See **Focus.**

PRINT HANGER.—A small contrivance for hanging up prints that cannot be dried between blotting boards.

PRINTERS' INDICATOR.—A small brass instrument that can be attached to printing frames. It contains two dials with figures, and two movable hands; one hand indicates the number of prints required from the negative, and the other the number already printed.

PRINTING.—This term is applied to a very large variety of methods of obtaining positive pictures from the negative, on paper, glass, wood fabrics, and other suitable materials. The principal process of positive printing is that known as the albumenized paper process, and it is that method which will be treated upon here. The other methods of printing upon bromide, platinotype, gelatino-chloride, and other papers, as well as upon glass, wood, silks, etc., are all treated upon under their respective headings.

The Printing Room.—This should be as large as possible, well ventilated, well lighted, and with suitable heating arrangements for the winter months. The temperature should be kept as nearly even as possible, as heat and cold have considerable effect upon paper and chemicals. The *sensitizing room* should also be well ventilated and lighted by yellow windows or by gaslight. Both rooms should be kept scrupulously clean.

Under **Albumenized Paper** will be found the method of preparing the paper with albumen containing a chloride. This can be, and is, usually bought ready prepared. The next process is to sensitize it by floating on a bath of silver nitrate. The usual bath is made up as follows :‡

* German Patent No. 43,455/ga.
† "Photography in Aniline Colors," By A. G. Green, C. F. Cross, and E. J. Bevan.
‡ See Silver Bath.

Silver nitrate	40 grains
Water	1 ounce

In summer the strength of the silver should be slightly decreased, and in winter slightly increased ; in the one case 35 grains to the ounce being used, and in the other 45 grains.

The addition of other nitrates to the sensitizing bath is often recommended for various brands of albumenized paper. The commonly used formula is this :—

Silver nitrate	40 grains
Ammonium nitrate	20 grains
Water	1 ounce

To this a few drops of ammonia are added till the solution is slightly alkaline. To the same bath the addition of five grains of lead nitrate has also been recommended.

On this bath the paper is floated for from forty to eighty seconds in the summer, and from seventy to 120 seconds in the winter, and afterwards hung up to dry. For further details of the sensitizing manipulations see under **Sensitizing.**

The Drying Room should be kept quite clean, and heated with a small stove, over which should be hung a rack fitted with wooden clips to suspend the paper. Drying the paper spontaneously is undoubtedly a mistake, as the silver then sinks into the paper, and the brilliancy of the surface is lost.

Fuming.—Before printing many operators subject the sensitive paper to the fumes of ammonia. By this means much richer and finer tones are obtained. The paper is placed in a box having a false bottom perforated with holes, and beneath which is laid a tray containing strong liquor ammonia. It is very necessary that the fumes be equally distributed on the paper to avoid patchy and unequal prints. In damp weather it may be found advisable to slightly dry the paper before fuming.

Cutting the Paper.—This is best done with an ivory paper-cutter. Many operators cut the print to the exact size required for the finished print. This is not advisable, however, as the subsequent operations will very often destroy or mar the edges, and much loss is sustained in consequence. Never try to secure too many prints from one sheet of paper, but allow of a comfortable margin above the size of the print required.

The Negative.—Before attempting to make prints from an negative it should be carefully studied, and the best method of treatment thought out. Thin negatives should be printed in a soft, weak light. A piece of white tissue paper stretched over the frame will secure the required effect.

Weak, flat negatives should never be printed from unless necessary. They can sometimes be improved by coating the back with a varnish tinged with iodine. The varnish is then scraped away behind those parts required to print deeper, and those parts required to print lighter may be treated with the pencil or Indian ink. Another method is to paste a piece of tissue paper behind and work upon it with the pencil. A strong bath should be used in sensitizing, and the time of fuming doubled. By printing under green glass greater contrast is obtained. See **Green Grass.**

Dense negatives with strong lights and black shadows, with little gradation between the two extremes, should be printed in a very strong light, preferably sunlight. It is also advisable at times to slightly expose the paper to light to soften the glaring high-lights.

Broken negatives should be carefully put together, and a piece of unsalted paper glued firmly to the glass side. When dry the paper will contract slightly and draw the parts closely together. In printing, the frame is laid on a board, kept revolving by means of a meat-Jack or other contrivance, so that the light does not come from one side only. The paper can be made translucent by any of the known methods.

Filling the Frames.—There are two methods of laying in the negative; it can either be placed directly in the frame, or made to rest on a thick piece of plate glass previously inserted. This glass must be kept thoroughly clean on both sides. The negative must also be dusted on the film side and well cleaned at the back, all pieces of emulsion and other foreign matter being carefully removed.

The description and illustration of the printing frame is given under that heading.

Every care must be taken to guard against breakage of the negative. This can easily be effected by many ways—by dropping carelessly in the frame, warpage of the wooden frame, unequal padding or backing, improper placement of the backboard, pieces of grit or other substances between the negative and the glass plate.

After placing the negative in the frame the sensitized paper is laid on it in the required place. This can be ascertained by holding the negative and paper up to the light while adjusting the latter in position.

Behind the paper pads of blotting-paper or felt cloth are placed to ensure even contact of the paper with the negative. This should not be too thick or uneven. The backboard is then inserted, and should fit properly, and the pressure given by means of the springs or wedges should be perfectly even all over; not too strong, or the glass may break, but sufficient to hold the paper firmly in place and prevent it slipping when examining.

The cutting of the paper, filling the frames, and examination of prints should all be carried on in a weak or yellow light.

Save in exceptional cases, as, for instance, with dense negatives, the exposure should be made in a bright light, but not sunlight. Care must be taken to protect the frame from shadows, stray lights, or reflections.

After a little time, the frame should be carried into the weak or yellow light, and the print examined by turning back half the backboard and carefully lifting up the sensitized paper. This operation is repeated at intervals until the print is finished. In examining prints never expose them to direct light, or the purity of the lights will be ruined.

The color of the print should be darker than required for the finished picture to allow for the loss which takes place in the subsequent operations. Experience alone will guide the operator in judging the right time to remove the print from the printing frame, as, to a certain extent, it depends upon the kind of toning bath used, some reducing the color of the image more than others.

Vignetting, *Combination Printing*, *&c.*, will be found under those headings.

PRINTING FRAME.—A frame in which the sensitive surface of the paper is pressed into close contact with the face of the negative while it is being exposed to the light.

The ordinary printing frame consists of a wooden box-shaped frame, having a hinged lid to allow of the examination of the picture during the printing process. (See Fig. 358.) In choosing a frame the points to be observed are—First, that it is carefully made and perfectly square and true, otherwise the negative is liable to get broken when the pressure is put on. Secondly, the back should be hinged perfectly level, the joint allowing of no light to pass through. Lastly, it should be so arranged that there is no fear of the print or the negative shifting during any of the operations.

FIG. 358.

Durnford's frame is a very light and handy contrivance; it consists of a hinged backboard only, the negative being kept in position by springs.

In printing out upon glass or opals a specially constructed frame is required. A clever contrivance is that devised by Cowan. It is a frame made specially for printing out opals which are required to be examined during the progress of printing without fear of movement. It is also provided with a simple means of adjustment to allow for the various thicknesses of opal plates and negatives without fear of breakage. For the printing of transparencies, provision is made for the inspection of same during printing through the opal. The frames are supplied with opaque masks, square and oval, to which the negatives are attached, and these are held in position in the frame by means of a hinged bar of wood and brass spring. The mask also serves to prevent the deep printing of the margins of the negative, which take up so much gold in toning. To attach the negative to the mask use a daub of the wax compound at the corners, and then lay on it the opal plate; and on its four corners at back also daub the wax. The hinged back is then shut down, and the composition causes the opal to adhere to the back of the frame; thus it can be lifted to allow of examination during printing.

For printing lantern slides from large negatives by contact, a frame constructed by Messrs. Adams & Co. is probably the simplest and handiest form. Fig 359 will show the plan adopted, whereby any part of the negative can be printed from, and not only any part but any angle. Two other advantages are, no risk of breaking the negative, and by means of wedges many slides may be made exactly the same as each other.

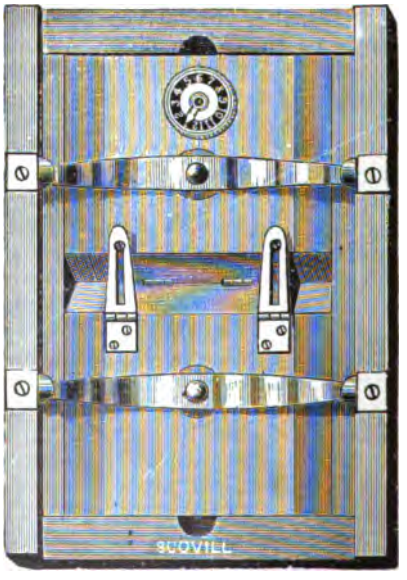


FIG. 359.—PRINTING FRAME

PRINTING IN.—A term used in combination printing when clouds, figures, etc., are afterwards added or printed in, the spaces for their insertion having been previously masked out.

PRINTING INK.—A compound of linseed oil and lamp or ivory black. The oil is boiled, the lampblack and other ingredients added, and the compound ground. There are a great variety of recipes.

PRINTING OUT.—A term applied in photographic printing to those processes on which the image is entirely produced by the action of light in contradistinction to other processes in which the image is either invisible or but slightly visible, and is afterwards completed by development.

PRINTING ROOM.—See **Printing.**

PRINTS, COLORING.—See **Photographs, Painting.**

PRINT.—A positive image obtained either directly or indirectly from a photographic negative, as silver-print, Woodbury-print, etc.

PRINT TRIMMER.—See **Knife.**

PRINT WASHER.—See **Washing.**

PRISM.—Any transparent medium comprised between plane faces usually inclined to each other. The prism generally used for optical experiments is a right triangular one of glass, the principal section of which is a triangle. It is used to refract and disperse light. If a ray of white light be passed through, it is resolved into its component colors (see **Spectrum**). A prism is also used in photography for producing reversed negatives (see **Reversed Negative.**)

PRISMATIC COLORS.—The colors into which a ray of light is decomposed by passing through a prism.

PROCESS BLOCKS.—Printing blocks obtained by the aid of photographic processes. The following excellent instructions for the production of half-tone or process blocks by the modern methods are given by Mr. Robert Whittet:—

Initiatory Operations.—The process in its entirety consists of three distinct operations: 1. Making the negative. 2. The preparation of the metal plate, zinc or copper, to be engraved. 3. The etching; to which might be added a fourth, the mounting of a plate on a wood block preparatory to printing, but which is so entirely dissimilar from the process of engraving, and so purely mechanical, that it may scarcely be considered as belonging to it further than necessary to make available to its ultimate purpose the plate which has been already completed so far as engraving is concerned. These several operations we will endeavor to explain in as minute and practical a manner as possible, both as to formulæ and method of manipulation, so that the tyro may attain to a degree of excellence proportionate to his intelligent apprehension and diligent and persevering prosecution of the methods described.

The Negative.—Gelatine dry plates are now specially manufactured with a view to suiting the process, and no doubt when the light employed is of a character that will secure steadiness and uniformity—as when the electric arc light can be made available—these will be found very convenient; but as the novice will probably be dependent on the ordinary light from the luminary of day, which is so very variable and liable to cloud and shadow, the dry plate would be found too uncertain in result, and the consequent waste too expensive for the beginner. He will hence find it most economical to adopt the wet-plate process of the old time photographer. In prosecution of this his first intention will be to the choice of glass, for which he will find crystal plate, about one-eighth of an inch in thickness, to be the most suitable, by reason of its being uniformly clear and free of bubbles and scratches. There are other makes, however, of varying excellence, and it will be well to see that what he uses is of good clear color, flat, and as free of imperfections as he can procure it.

Cleaning the Glass.—Having procured the glass, the next operation is to have it thoroughly cleaned; and in this, as, indeed, in every subsequent part, scrupulous cleanliness is a *sine qua non* to success. This is best effected by allowing it to steep in a strong lye for several hours, say over night, and after a thorough rubbing on both sides with a piece of clean coarse cloth under the tap, put it into a dilute solution of nitric acid—of, say, three ounces to the gallon of water—and let lie for at least a half a day, and none the worse for a longer time. From this it should be again washed and rubbed with the canvas cloth under the tap, until it is seen to be absolutely clean by examining it toward the light. It is sometimes found that the water from the public reservoirs, from impurities held in solution, leaves a stain or cloud on the plate after drying; in such case it will be needful after washing to give a last rinsing in pure water, either distilled or melted ice, filtered, which may be contained in a dish laid conveniently for the plate to be laved in it.

FIG. 360.—HOLDER FOR GLASS PLATE WHEN CLEANING.

Albumenizing the Glass.—The next operation is the albumenizing of the glass. This

is necessary as a substratum for the collodion to be afterward flowed over it. This is done immediately after rinsing from the pure water last used in washing. The proportions of albumen to water are very varying among operators in practice, some using the white of one egg to twenty-five ounces of water, while others give to the same quantity of albumen eighty ounces of water. Any proportions between these will work, the main idea governing being the injury to the silver bath, which may result by the gradual communication to it of organic matter from this source. It will readily be understood, however, that a very thin or delicate solution is all that is necessary, and the white of one egg to forty-eight ounces of water will be a desirable medium to adopt.

Albumen Solution.—To prepare the albumen solution take the white of a fresh egg, careful that none of the yolk or the germ is accidentally admitted. Break this into a froth with an ordinary egg-beater, and mix with forty-eight ounces of water. This should be the purest procurable, distilled, or from melted transparent ice, and filtered before use. Thoroughly mix by beating again with the egg-beater ; neutralize by adding five or six drops of acetic acid, and let stand over night. Before using, it must be frequently filtered through absorbent cotton until it is seen to be thoroughly clear and limpid, and with no shreds of albumen visible. To get it to this condition will necessitate filtering three or four times, and it will be found most convenient to take several graduates of varying sizes with a funnel containing the cotton in each, and pass from one to another, till the last be found in condition of sufficient purity to be flowed over the plate.

Flowing the Plate.—With the glass perfectly clean, immediately after rinsing in pure water, as above recommended, take the graduate containing the last filtered albumen solution in the right hand, while the glass is held in the left by the lower left-hand corner ; pour the solution copiously on the plate at the upper right-hand corner, and allow to flow gradually over it and run off at bottom. Flow at least twice, as much as possible preventing any from reaching the back, because of its not being necessary there, and of the injury it may afterward inflict on the silver sensitizing bath. After flowing twice, set up the plates on a rack to dry spontaneously, being careful to arrange them with the albumen side turned one way, as it is hardly possible to discern after drying which side has been albumenized. After drying, they may be stored in some convenient cupboard or shelf, and protected from dust by a cover being kept over them. Any number may be thus prepared at once, as they will keep for any length of time.

The Collodion.—The next further stage in the process is the preparation of the collodion. This may be purchased ready prepared, but no work on the subject would be complete without the formula for making, and its preparation presents no great difficulty. There are many recipes, varying somewhat with the fancy which some operators think they have discovered in a few grains less or more of some one or other bromide or iodide salt, but all practically bringing out the same result ; the supposed excellence of one more than another probably resulting from the methods of handling the after operations. The following will be found to be one of the best :

Alcohol, 95 per cent	8 ounces
Iodide of ammonium	48 grains
Iodide of cadmium	24 grains
Bromide of cadmium	16 grains
Pyroxyline	120 grains
Sulphuric ether	8 ounces

Dissolve the salts by grinding each separately in a mortar with a portion of the alcohol in the above order; add the pyroxyline and shake well; last, add the ether, and, after shaking, the whole will be seen to dissolve into a clear liquid of amber color. It will be sufficiently ripened to work in a few hours, but will improve as it gets older. The ether being very volatile, it should be kept in glass-stoppered bottles. There are bottles manufactured for the purpose—"collodion pourers"—but in the absence of these an ordinary wide-mouthed bottle with glass stopper is an excellent substitute. The most convenient shape is that shown in Fig. 361. It allows all impurities to settle in the bottom, so that the collodion may be poured out without disturbing them, and the formation of the bottle is also such that air bubbles are not formed when pouring out the solution.

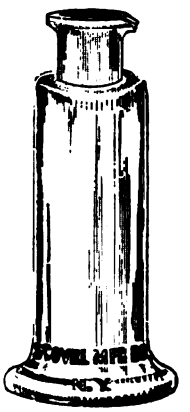


FIG. 361
COLLODION BOTTLE.

Flowing the Collodion.—To so flow the collodion over the plate as to give a uniform coating requires a little dexterity that can only be acquired by practice. Take hold of the glass by the lower corner in the left hand, stretching the forefinger along the edge so as to give support at that point, while the thumb and middle finger support the bottom (see Fig. 362). Now, holding it as level as the eye can judge, pour a pool of collodion about the center, or nearer the top, of the plate with a steady, even flow, and of sufficient quantity to cover it. Incline the glass so as to make the collodion flow first to the upper right-hand corner (to No. 1), then over to the left (to No. 2), and then down to the bottom (to No. 3), allowing the surplus to flow off at the lower right-hand corner (at No. 4), into a wide-mouthed bottle, kept for the purpose,

and fitted with a stopper or cork. This can be afterward utilized by filtering, and adding to the stock bottle.

The important object is to have a regular coating all over the plate; and to attain this there must be no hesitation in the pouring and flowing over the whole surface, and then, by raising it into a perpendicular position, allow the surplus to drain, at the same time giving it a to-and-fro motion sideways, but by no means such as would send it back over the plate. Having an eye to the careful preservation of the silver bath, wipe off all superfluous collodion that may have got on the back of the glass. It would set in a few seconds, indicated by its drying or thickening so as take the impress of the thumb at the lower corner where last poured off. Whenever this is noticed it is ready to be lowered into the sensitizing bath, which should be done without delay.

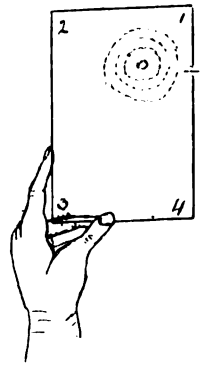


FIG. 362.

The Silver Bath.—It is very important that the silver bath should be made from the purest materials. The water especially should be carefully filtered and purified. The most efficient method of accomplishing this is to take distilled water, or transparent ice melted; add to it a few crystals of nitrate of silver, put into a bottle of white glass and set in the sun. In a few days it will darken corresponding to the amount of organic matter contained in it, which will be precipitated and can be filtered out. Make up a sufficient quantity to fill the bath holder of the size determined upon. This may be a flat dish—which will call for a less quantity of silver, but not on that account more economical—or a regular glass holder with box and cover, which is greatly to be preferred, being much more easily managed in respect of the plate, but also for keeping the bath in better condition (see Fig. 363). A size 11 x 13 will be found a serviceable and convenient size to work with. This will require 100 ounces, which should be of the strength of 40 grains to the ounce, tested by an argentometer (Fig. 364). Put this quantity into a large bottle of white glass, add to it a few drops of concentrated anmmonia, to neutralize, until it just turns red litmus paper blue, and set it in the sun for several days to clear. Any organic matter contained in it will be precipitated, or adhere to the sides of the bottle, which must be thoroughly filtered and cleaned out. Filter again and again until assured of being thoroughly pure, by its remaining clear. When ready for use, put into the bath holder, add a few grains of iodide of potassium—5 grains will be sufficient—and of nitric acid, C. P., a few drops at a time, until it turns blue litmus paper a decided red, when it will be ready for use. In place of adding 6 grains of iodide of potassium, a collodionized plate may be placed in the bath and allowed to remain over night, when sufficient of the iodide will have been communicated to it from the collodion.

FIG. 363.—SILVER BATH.

The Care of the Bath.—The care of the bath is a matter of much importance, as it is liable at times to go out of order for causes not easily discoverable, there being many that affect it, which may set their evil influences into operation suddenly; but the chief source is from organic matter introduced through the medium of the collodion and the glass plate, and should be carefully guarded against. In time it will have become so surcharged with alcohol and iodine from this source as to require doctoring, which condition may be known by the developer flowing over the plate as if meeting with a greasy resistence, and later by minute pin-holes like star dust being observable in the negative. The first of these may be corrected for a time by the addition of a little alcohol to the developer; but be assured that the other is not far away, and then it will be needful that drastic measures must be adopted. To this end take a quantity of pure distilled water, or melted ice purified, equal to the bulk of the bath; pour the bath into it, filter out the iodides and simmer down by gently boiling in a granite or porcelain dish (Fig. 365.) until it is reduced to considerably less than the original bulk. This operation will have evaporated out the alcohol. Let it now be brought to the strength of 40 grains to the ounce, by the addition of pure water, neutralized by the addition of a few drops of concentrated ammonia, and set in the sun, where the organic matter will be precipitated, and may be filtered out. A longer sunning and filtering will further improve it, and after assurance by its remaining clear, it may be acidified as at first, and again put to work. Because of the liability of the bath to go out of order, it is well to have one or

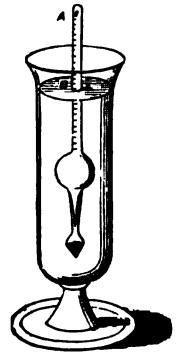


FIG. 364.
ARGENTOMETER.

two distinct baths under process of sunning and purifying, besides the one in use, and so save disappointment at inopportune times Before beginning the work of the day the bath should be skimmed over with a piece of clean blotting paper.

The Dark-Room.—The dark-room should be arranged with everything so conveniently placed as to be readily found in the dim light necessary. This need not be so very dim, however, as to become a source of confusion, the wet-plate not being nearly so sensitive as the gelatine dry-plate of the photographer; but the light must be made non-actinic in character, by being strained through a colored medium, either of glass, cloth or paper, that it may not affect the sensitized plate while it is being taken out of the bath and placed in the camera-holder. If the light is taken from an outside window, it may be partly blocked out, while a portion may be covered with orange-colored cloth or paper. A clearer light will be obtained in which to observe the action of the developer, by placing a pane of ruby-colored glass into a section of the sash. If dependent on gas or artificial light it should be enclosed in a lantern or other enclosure, and protected by ruby or orange-colored glass. The incandescent electric light is very convenient when it can be readily obtained. The sink and water-tap should be so placed with relation to the light as to be readily accessible at the moment development is seen to have reached the desired amount of detail.

FIG. 365.—EVAPORATING DISH.

Sensitizing the Plate.—The bath having been prepared and in working order, the next operation is to make sensitive to light the glass plate. This having been flowed with the collodion as described is laid on the dipper, and a steady, unhesitating motion, lowered into the bath, stirring it a few times, but not raising it so high as that any part of it will be out of the solution. This may be done with the full light up in the dark-room; but in placing the plate into the bath let it be shaded by the person or otherwise, until the cover is placed over it, otherwise "fog" may be the result. It should be allowed to remain in the bath until sufficiently sensitized, for which five minutes is about right, though with a bath that has been some time in use a few minutes more will do no harm.

In taking the plate from the bath, raise the dipper with the same steady motion as in inserting, as any stoppage will surely leave a mark across the plate. Allow to drain for a few seconds, and then set against the wall or other support, and wipe the back with blotting paper, and place in the camera plate-holder, which has been previously set to fit the plate and screen. As heretofore arranged the screen and its frame or holder is of size to fit the size of plate used; but recently a plate-holder has been invented accommodating any size of screen or plate, and with a device by which the separation of the screen and plate may be regulated to a nicety, which must prove a valuable adjunct to the working plant of the process worker (Fig. 366).

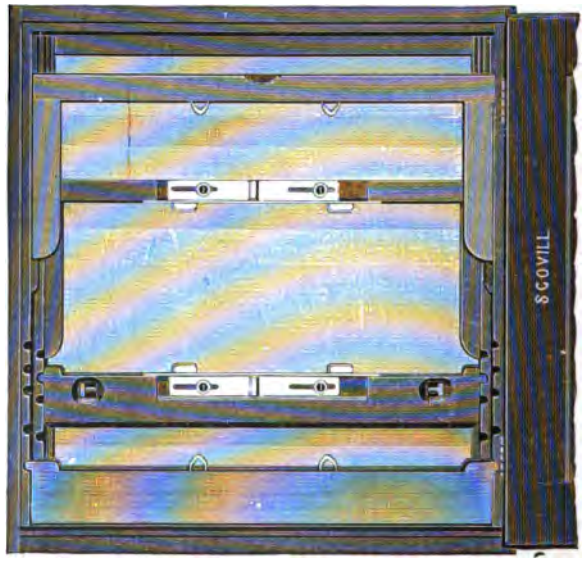


FIG. 366.—SCOVILL SCREEN PLATE HOLDER.

The Screen.—At this point it may be well to consider the screen and its use. It is an indispensable accessory to half tone work, for without its assistance it would be impossible to etch plates from photographs or wash drawings capable of being printed by the typographic process. By its influence the picture is broken up into minute points, which present a surface to the inking rollers of the press, without filling up the interstices between, and so preserving the picture. According to the fineness of the ruling of the screen will be the fineness of the resulting print, but, on the other hand, it will call for superior paper being used and greater dexterity in workmanship in the printing. The fineness of the screen should therefore be commensurate with the ultimate intention in the use of the engraved plate. If it is to be printed on a common quality of paper, then a screen of coarse ruling—say of 80 lines to the inch—should be employed, while screens of from 132 lines and up to 175 will necessitate the finest coated paper and the most skilful presswork. For more ordinary work screens of 120 to 124 lines to the inch will be found most serviceable, but to get the best results out of these a good coated paper and an experienced workman at press is needful.

Distance of Screen from Plate.—But a matter of much importance in working with the

screen is the distance of separation between it and the sensitized plate. This distance will range from one-sixteenth to one-eighth of an inch, to be regulated according as the desire of the operator is to get the high lights up without using a larger stop, or giving longer time of exposure. The use of the screen in this respect will be understood when it is pointed out that the influence of the wider separation is to allow the light so much more space in which to spread, and thus fill up the high lights. With this fact kept in mind a wide field is open for experiment, and the acquisition of practical knowledge, which can only be thus attained.

FIG. 367.—PLATE VISE FOR HOLDING GLASS WHEN BEING POLISHED.

Cleaning the Screen.—It is of the utmost importance that the screen be absolutely clean, and to get it so is more difficult than might be expected, the smallest stain from the fingers or other source being observable on the negative. Perhaps the simplest way to clean is to fix in a screw vice, which is made for the purpose, and not costly (see Fig. 367) Keep a little of the finest French chalk mixed with alcohol at hand, and apply a few drops, rubbing over the surface, afterward polishing with a little pure alcohol or distilled water, applied with some absorbent cotton, and lastly rubbing up with a clean bit of soft, old silk. It takes a close scrutiny to discover streaks, and a careful examination in all lights is necessary.

The Camera.—Having inserted the sensitized plate and closed the holder, the next operation will be with the camera. This should be of size to accommodate the screen and plate chosen, and be erected on a platform on which it can be made to slide far enough for considerable reduction being made. There must be perfect vertical alignment between the camera and the picture to be copied, and this is best attained by the copy-holder being placed on the same platform, and also made to slide on it (Fig. 368). A platform about 10 feet long will be found a useful length for ordinary work. It may be conveniently erected on a table with castors that it may be readily moved about, and springs that may counteract any vibration that may occur during exposure. The camera and copy-holder being placed on the same platform, any vibration occurring will be imparted to both plate and copy alike. Another method of counteracting any vibration is to suspend the platform with camera and copy-holder from the roof; but unless the operator's light is from a steady source the former plan will be found most convenient, as it can be shifted about so as to suit the direction of light at any time of day. Fig. 369 will explain what is meant.

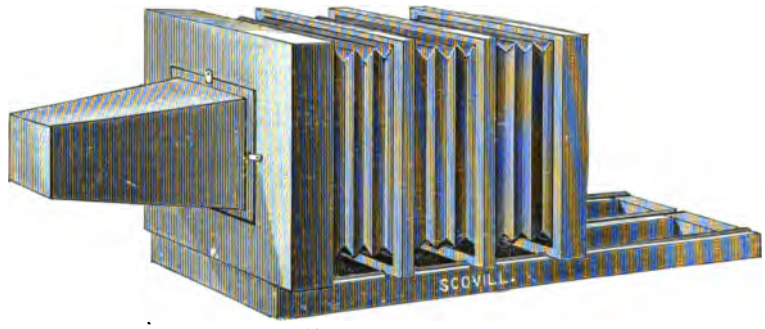


FIG. 368.—COPYING CAMERA.

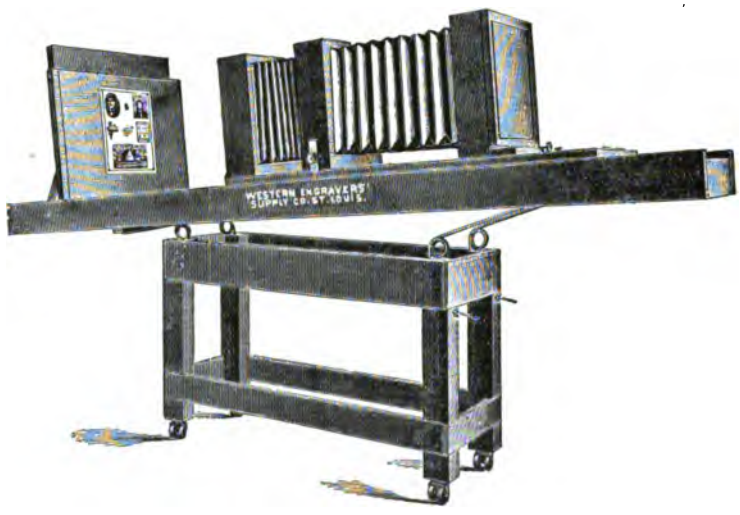


FIG. 369.—CAMERA STAND.

The Lens.—The lens is perhaps the most important item of the process worker's outfit. There are many good lenses on the market, and those of any of the reputable makers will afford a guarantee of suitability. It will therefore be the truest economy to procure the best the intending operator can afford to purchase, and he has a wide choice. It should, however, be of the rectilinear class.

A lens that has met with considerable favor with half-tone engravers is the Steinheil Wide-Angle Aplanat, Series VI. (See Fig. 371.) It gives perfect flatness of picture and sharpness of image, together with considerable field.

The Diaphragms.—The diaphragms or stops, as more familiarly spoken of, are an important

adjunct of the lens, and considerable judgment is necessary in the use of the several sizes, which can only be acquired by experience. It should be kept in mind that they are related to each other by regular gradation, and that the diameter of each is a proportion of the length of focus of the lens. The gradation followed as a rule gives a value double--*i.e.*, admitting double the amount of light—that of the smaller one immediately preceding. One or two general rules regulating their use may be laid down for easy remembrance: 1st. In copying a picture and making a considerable reduction, use a small stop, commensurate with the amount of reduction. 2d. A small stop gives greater detail in the shadows, sending the light rays more directly, or in straighter line, through the screen. 3d. The larger stops allow the light to spread, and so have relatively a greater influence in filling up the high lights. Keeping these rules in view, it will be readily comprehended that the use of too large a stop will fill up the high lights of the picture before sufficient detail could be got in the shadows, and the inference naturally follows that when a lack of detail is observed a smaller stop should be used. The character of the picture to be copied has also to be judged, and as a rule, should it contain much of dark shadow, a small stop and longer time of exposure is indicated, so as to get enough of detail. It is a good method and will bring out the best results to use several stops--say, two or three--and proportion the time with each as to give detail in the shadows by so much given with the small stop, so much more given with the next larger, and possibly a shorter exposure with a still larger for the high lights. It is well to aim for getting the high lights right, the detail in the shadows being more easily got by giving more exposure with the small stop.

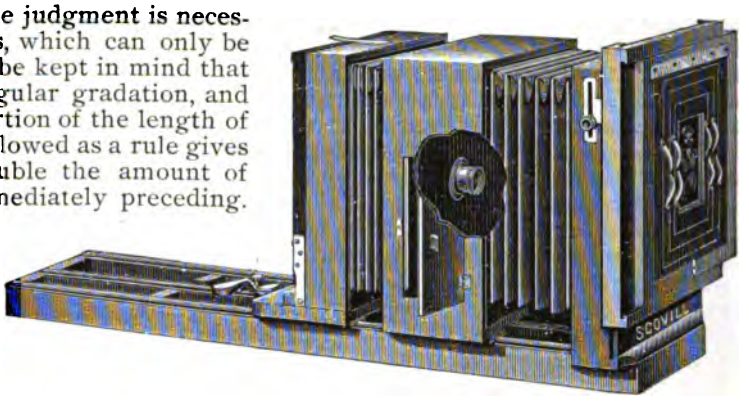


FIG. 370.—ENLARGING AND REDUCING CAMERA.

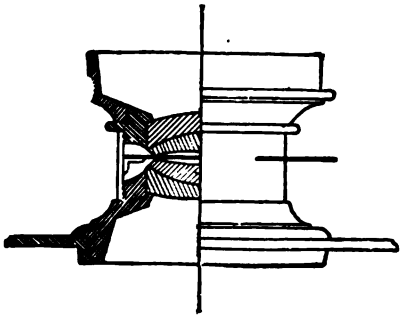


FIG. 371.—STEINHEIL LENS.

Diaphragm Apertures.—The stops or diaphragms sent with lenses as purchased usually have their apertures round in form; but recent investigation has shown that other forms may be used with advantage. Square apertures, or square with the corners cut out, also diagonal, as follows, are each seen to have a varying influence on the shape of the dot, and through it on the picture resulting. Every square in the screen acting as a separate lens causes the dots to partake of the shape of the apertures used. This investigation has been very fully made by Dr. J. M. Eder, of Germany, and Mr. Levy, of Philadelphia. The latter gentleman gave the result of his investigations in a very interesting article in the *Paper and Press*, and has invented a form of diaphragm in which the shape of the aperture may be modified or changed, as shown in Figs. 373–376. The elaborate writing of Dr. Eder has been translated and published in the *Process Photogram*, of London, England, and from it we extract the following paragraph, as presenting the gist of the whole:

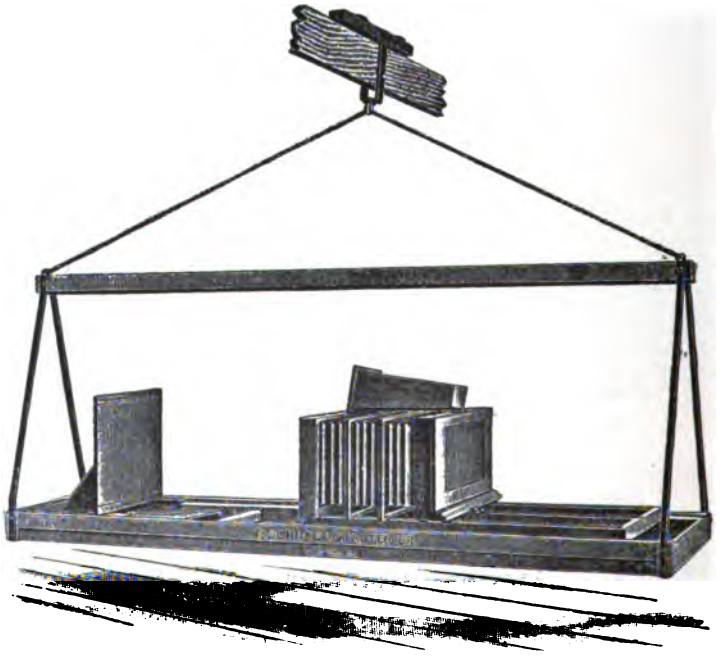


FIG. 372.—CAMERA SWING.

"With square diaphragm apertures the preparation of half-tone negatives is rendered easier and more certain than with round ones; the reason of this lies in the fact that the corners of the square negative dots in the high lights beauti-

fully coalesce, by which means the dot remains open, so that the square stops—even if their ratio aperture may not be so great as that of the round ones—it is easier to obtain undulated half-tone negatives. Square stops with the corners cut out I especially recommend for half-tone work; the beginner should commence his experience with such a stop. The influence of the diagonal aperture is to present the dots in lines, and this will be more readily observed if one-half the time allotted to this form be given the one way, and the diaphragm turned round so as to give it in the other direction. These special diaphragms may be made in cardboard and blackened."

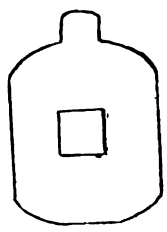


FIG. 373.

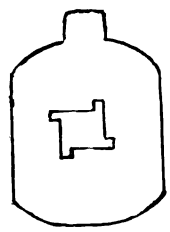


FIG. 374.

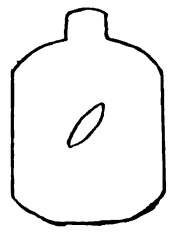


FIG. 375.

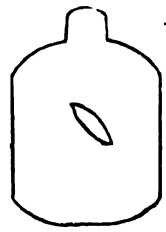


FIG. 376.

The Copying Board.—The copying board should be so placed as to be conveniently shifted to accommodate any reduction or enlargement that may be required, but at the same time retain its being in position perfectly vertical to the camera holder. This is secured by being erected on the same platform as the camera, and running in the same grooves, as explained in the foregoing diagram. The copy may be affixed in any way convenient, only where special means have to be adopted to keep it flat, perhaps the simplest way is to place a piece of plate glass over it, for which it is as well to make provision, so it may be readily fixed and at the same time impinge with some pressure on the copy. With a couple of catches of thin brass at the bottom, to support the weight of the glass, into which a wedge of folded paper may be pushed to keep it tight, and pieces of spring brass at sides and top, secured with a screw at end, so that it may turn in any direction and hold, it will be found all that is needful (see Fig. 377.) In the use of a plate glass cover, however, it should be seen that no reflections proceed from it, and if there are, means must be taken to obviate them. And this leads us to the next important consideration, that of

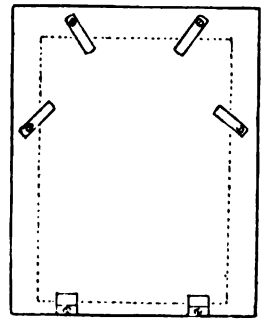


FIG. 377.

Light.—If you have access to the skylight of a photographer's gallery, or can erect such, you are all right, and have at hand a most potent assistance in securing suitable negatives with greater certainty and with less perplexing judgment. But you may be dependent on a side light from a window, with every variation of cloud and sunshine, rain or clear weather, while volume and intensity will also vary with the season, and it will call for the exercise of much study and waste from many trials on plates, and patience, to secure the exact conditions of a good negative. A northern light will give the most steady and have less variation, but more frequently one has to make the most of what he can get, and then it lies for the man of inventive parts to bring out good results from circumstances as he finds them. Direct sunlight may even be used, and good negatives secured by it with very much shortened time of exposure.

Exposure.—The varying circumstances of light—the fickle clouds and the uncertain haze, the meridian glare and the slanting ray of the morning and evening, as well as the summer's glow and the winter's mist—render the time of exposure a matter of exceeding difficulty, which experience only can overcome, and enable one to attain to the exercise of a just judgment. It may be mentioned, however, that an exposure through a screen for a half-tone negative will take about four times that of a negative intended for line work. Before uncapping the lens examine the conditions of the light, and determine what stops you will use, and mark down on a slip of paper the time you intend to give to each, then turn the hands of a striking clock to the time allotted to the first stop, and the instant of its striking will give a perfect warning that time is exactly up, when the lens may be capped and the stop changed, and the clock again set to keep its vigils for the fullness of time.

Exposure Example.—As an example of approximate timing, we will suppose a picture to be copied, and to be reduced to about one-half. Referring to what has been said regarding stop apertures on p. 408, we would use that marked No. 1, or a round aperture of same size, say *f*/75, and give seven minutes; then change to No. 2, *f*/50, and give two minutes; change again to Nos. 3 and 4, same size, and give one minute each; being eleven minutes in all, with a fairly clear light, through a screen of 120 lines to the inch, and with a rapid rectilinear lens of a reputable make. The light, or other circumstances, may call for a different exposure, but this is given as an example that will be found nearly correct.

The Developer.—Make a saturated solution of the proto-sulphate of iron, of which take twelve ounces, and add to it two ounces of acetic acid and twenty-four ounces of water. Some add a little alcohol, but this is not necessary unless the silver bath is getting out of order from use, or the accumulation of iodide, alcohol, or organic matter in it, which may be known by a difficulty in flowing the developer over the plate, and may be accepted as a warning to see after a new bath, and an early rectification of the old.

The Fixing Chemical—The agent used to fix the picture, or destroy the sensitive character of the plate, is the cyanide of potassium, made up in solution in the proportion of one ounce of cyanide to twelve ounces of water. It is highly poisonous and should be carefully kept from any scratches or abrasions on the hands, and so save any risk of blood poisoning.

Development.—The exposure made, retire with holder to the dark-room, which we have supposed to have been fitted up with sink, water, and the usual necessary equipment of such "dens." The developer and the fixing chemical are supposed to be lying convenient to hand. Take the plate from the holder, and, holding it by the corner in the left hand, flow the developer with a steady and rather copious sweep over it, yet permitting as little as possible, or none, to overrun. Flow back and forth until the appearance of the image, which, if correctly timed, should be in a few seconds, and watch for the coming of the details of the picture, and on the instant that they are seen to be sufficiently full, stop further development by putting the plate under the tap, and letting the water flow freely over it. Guard against over-development. If allowed to go too far there will be a veil or fog over the plate, which it is difficult to get rid of, with great risk of spoiling the negative in the attempt.

Trimming the Negative.—The development having been carried as far as desired—*i.e.*, with the detail fully out, but no more—and washed with a generous flow of water, it is now ready for being "fixed," that is, the image rendered non-sensitive to the light, which is done by flowing over the plate the before-mentioned solution of cyanide of potassium, when the whole picture will be seen immediately to clear up. Before doing so, however, it is well to trim up the negative by scraping away with the thumb the film from the outer margin of the picture, allowing about an inch or so to remain. As the film is very rich in silver, a small receptacle should be provided, easily found in the dim light of the dark-room, where that portion scraped off may be put and preserved.

Examination of the Negative.—The plate may now be taken into the light and examined through a microscopic focusing glass, and the attention first directed to the condition of the dots seen in the high lights, *i.e.*, the dark portions in the negative. These will have come right, if they almost, but not quite, touch each other, while the dots in the half-tones will be of size varying as they tend to light or shade, and the deeper shadows will have smaller dots, but sufficiently pronounced to permit a little diminution in the after process of clearing. Should the high lights not be closed enough, and instead show considerably wide cross lines, then a longer exposure with the larger stop, or possibly increasing the distance a trifle between the screen and plate is indicated. If the dots in the shadows are not sufficiently strong, then a smaller stop, or a longer exposure with the smallest stop used, is the remedy. Keeping these rules in mind, with a little practice, the operator will soon master the principles and attain familiarity in working.

Intensification.—However well defined the image may appear on the plate at this stage, it is never so clear as that a satisfactory plate could be engraved from it. It requires to be "intensified." To do so there are two methods that may be adopted, both of which have their advocates. One of these uses the bichloride of mercury as the agent, the other employs a solution of the sulphate of copper and bromide of potassium with nitrate of silver. The formula and operation with the first are as follows:

Bichloride of mercury	2 ounces
Muriatic acid	½ ounce
Water	25 ounces

Allow the plate to remain in this solution till it is bleached white, when it should be well washed in running water, and then flowed over with the following:

Hydrosulphuret of ammonia	1 part
Water	4 parts

This will make the plate an intense black. After being well washed it should be flowed over with a weak solution of nitric acid, in the proportion of 1 drachm to 4 ounces of water, well rinsed under the tap and set aside to dry. It should be mentioned that the bichloride of mercury is the well-known corrosive sublimate, a deadly irritant poison, and should be used with extreme caution.

The formula and operation with the other method are as follows:

Sulphate of copper	25 grains
Bromide of potassium	15 grains
Water	1 ounce

Flow this solution while the plate is held in the hand. It will at first discolor or darken the film, but in a few seconds will bleach to white. After it has whitened through, let the tap flow over it till thoroughly washed, which will take about five minutes. The washing should be uniform all over, and if allowed to lie under the tap the water should be directed in an equal stream over all parts. It should then be flowed over with the following solution:

Nitrate of silver	40 grains
Citric acid	8 grains
Ice or distilled water	1 ounce

Under this application the plate will blacken over, when it should be again thoroughly washed.

Clearing the Negative.—It is more than probable that it will not yet have been sufficiently cleared to print, in which case it should be flowed with the following solution of iodine:

Iodine	40 grains
Water	4 ounces

with iodide of potassium added in small quantities at a time and shaken until all the iodine scales are dissolved. This will be of a deep brandy color. After allowing this solution to act upon the film a few seconds, it should be well rinsed in water under the tap, and flowed with a *very* weak solution of cyanide of potassium, which will instantaneously whiten over the film, and the image will be seen gradually to clear up. Great caution, however, is needful in this operation. Should the cyanide be too strong, or allowed to act too long upon the film, it will sweep away the dots in the shadows or cut away so much as to render the negative valueless. The tap should be kept running while operating with the cyanide solution, ready to stop its action the instant it is seen to clear up. If an examination reveals that it is not yet sufficiently clear, the operation may be repeated. Should any part be seen to require clearing more than another, a small stream of the cyanide solution may be so poured from the graduate as to be directed on the clouded part without reaching the rest, though to do so will require delicate handling and much caution, as, a little overdone at this point, the whole negative may be spoiled. When seen by examination with the focusing glass to be sufficiently cleared with the cyanide, it should be again well washed, flowed with the foregoing weak solution of nitric acic, and afterward blackened with the solution of sulphuret of ammonia mentioned above, flowed again with the nitric acid, washed and set aside to dry. Wash well after flowing with all the solutions.

Features of a Good Negative.—It is to be hoped that the result of so much labor, necesitating so much careful handling, and the exercise of so much judgment, will be a good negative. If it is not satisfactory it will be but labor lost to proceed further, and it will be well at this point to describe what constitutes a good negative. Give it a minute examination under the glass. The darkest portions of the negative, which will be the high lights in the finished picture, should present a small, clear, transparent dot. The effect of the intensification should have been to close up the black dots which, after development, almost touched. If there are cross lines of white instead of the small dot, the high lights in the finished picture will be correspondingly dark and the whole effect will lack contrast and pluck. The black dots in the half-tones should vary in size down to the very small in the deeper shadows, and where strong contrast is wanted they may in some portions be down to nothing. Should the finished negative not present these features, it were better, in the spirit of *nil desperandum*, to throw it aside, and begin again at the beginning, hoping for "better luck next time."

The Marginal Line.—The resulting negative proving satisfactory, the further operations may be proceeded with, and the next, unless a vignetted effect is wanted, a marginal line should be run around the picture, giving it a finished appearance, and affording a guide for the router in mounting. With a square or straight edge laid along the margin of the picture, run the point of a graver along; this will make a clean cut through the film, which will print black in the finished picture.

Turning the Film.—The film has now to be prepared for turning, otherwise the picture would appear reversed in the after printing. Though to turn it is by no means a difficult operation, it requires delicate handling, and is most interesting. To enable its being so turned it is first giving a coating of india-rubber dissolved in benzole, made as follows: Cut half an ounce of pure virgin rubber into small pieces, and place in a bottle with about 8 ounces of benzole, giving it a good shake occasionally. In a few days it will dissolve. It should be about the same consistency as good collodion, and if found too thick it may be thinned by the addition of more benzole. It must not be too thin, however, otherwise it will not be sufficient to resist the action of the collodion which is to be afterward applied and which would eat away and destroy the film. After the benzole has evaporated and left the rubber in a thin layer dry over the film, it must be flowed over in the same manner with "stripping" collodion, made after the following recipe:

Alcohol	4 ounces.
Pyroxyline	60 grains.
Sulphuric ether	4 ounces.
Castor oil	30 drops.

The castor oil is added to make the film adhere to the glass after being turned. It is ready for turning any time after the collodion has set and dried.

At this stage the film should be cut through with a sharp knife about a quarter of an inch from the line marking the margin of the picture. It is now to placed in a solution of acetic acid, of quantity sufficient to cover well, and proportioned as follows:

Acetic acid	1 ounce.
Water	8 ounces.

In a few minutes the film at the outer edges will readily be picked away by raising it at the corner with a penknife. After stripping away the outer portion, and leaving only the picture on the glass, put under the tap and wash well, but carefully, and lay on a table, with plenty of water upon it. Now take a piece of stout common printing paper, somewhat larger than the picure and within the size of the glass; wet it by drawing it through water, and lay it over the film; next squeegee the water from till smooth, raise the corner, and with the point of a penknife pick up the corner of the film, just enough to catch hold of it between the finger and thumb, keeping the paper for support, and gently pull both together from the glass. It will readily come away. Lay it down upon the glass, film up, and smooth out gently with the squeegee, or the point of the fingers, any wrinkles that may have come on it. If the wrinkles are numerous, or the film too delicate to handle with the squeegee or the fingers, a gentle flow of water will expedite the operation, being cautious, however, not to flow so sharply as to float it off! Now draw another piece of paper through water, and lay it over the film, squeegee again, and lifting both papers, having the film between them, from the glass turn right over, and remove the first piece of paper, which will now be uppermost. The film may now be lifted with its paper support and set aside, and the glass thoroughly cleaned under the tap. So cleaned, lay the glass on the table with plenty of water, lay the film, with its paper support uppermost, in the center, and squeegee the water from it. The paper may now be lifted and the film examined and smoothed out gently with the squeegee, and the paper replaced over it. With two or three layers of blotting paper over it, it should be placed under a board and a weight for about half an hour, when it may be taken out and set side to dry.

Preparations for Etching.—The negative is now ready for being printed from, and the student's attention will now be directed to the preparation of the metal plate for etching. This may be either of zinc or copper, the choice being determined by circumstances, it may be of economy or otherwise. It has been maintained by many excellent operators, especially in England, that one metal is as good as another, so far as the final results are concerned; but an examination of the work in America will satisfy an unprejudiced scrutiny that finer effects have been obtained on copper. It is possible that different ideas of what constitutes excellence in an engraving may account for the preference. It will be noticed that the American workman seeks after strong contrasts of light and shade, and, not content with that which his negative can supply, has recently resorted to putting the strong lights in with the graver, and by rubbing down the dots has strained after deeper blacks in the shadows. Our cousins on the other side evidently seek after softness of general effect, and by their writings on the subject show that they esteem this as the acme of attainment. Whichever metal is chosen, however, it must be perfectly polished. It may be purchased in several grades of preparation, rough, machine polished, or highly buffed. We think it the best economy to get at least machine polished, and we will assume that it has been so procured.

Polishing the Metal.—If the metal chosen be zinc, it may be brought to a good polish under charcoal and water, but with copper it is necessary to give it a fine grain with emery and charcoal and water, and lastly with charcoal and water alone. In polishing on either metal, let the rubbing be done all one way, to and fro, not in circles or across. After a partial polish, it is well to put it for a few minutes into a strong lye, to overcome any greasiness; and the hands should be perfectly clean, and the fingers not allowed to touch the polished surface of the plate for the same reason.

The Enameling Solution.—The plate being well polished, it is now ready to receive the enameling solution. For this there are various formulæ, each supposed to have merits of its own, and hedged around with all the importance of mysterious secrecy; but the bases of all is a glue or gum, preferably Le Page's fish glue, which is now specially refined and clarified for the purpose, while the sensitizing element is the bichromate of ammonia. To these most operators add a proportion of albumen, and the varying proportions of these ingredients constitute the virtues of the so-called secrets. Some, however, discard albumen, and as the presence of this prevents the keeping quality of the solution, it should only be made up in small quantities for early use, or not more than will suffice for a week or two's work. That made without albumen may be made up in larger quantities, as it will keep indefinitely; but it necessitates more careful washing out after development, the albumen, when used, washing out more readily. We give both formulæ, that the operator may take whichever, after practical experiment, he is most successful with.

Le Page's clarified fish glue	2 ounces
Bichromate of ammonia	120 grains
Albumen	2 ounces
Water	6 ounces

The whites of four eggs of medium size will yield the above quantity of albumen, which take, carefully excluding the yolk and the germ, and thoroughly beat up and set aside to settle. Grind the bichromate with the water, mix with the glue, and add the albumen, and beat up the whole again. A common domestic egg-beater is very suitable for this purpose. Make the mixture up in non-actinic or feeble light, and set aside for several hours, when it should be filtered through a small piece of fine sponge in a large funnel, and put into a stock bottle, and again filtered in the same manner before using.

The formula without albumen is as follows:

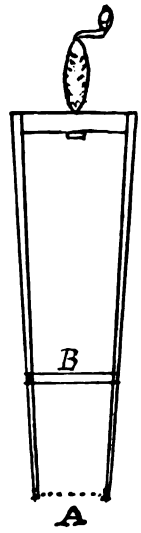
Clarified fish glue	3½ ounces
Bichromate of ammonia	80 grains
Water	10 ounces

The directions for making giving above will apply equally to this. They should be tested with litmus paper, and will more than likely be found acid. Neutralize with a few drops of concentrated ammonia.

Sensitizing the Metal Plate.—The plate having been cleaned and polished, let water from the tap freely flow over it, and, slightly draining the surplus, pour a portion of the solution on at the upper right-hand corner, when it will sweep the water from before it. The solution will have been filtered through a sponge and convenient at hand in the graduate. Flow a second and a third time. Let the surplus at the first flowing run into the sink; if that of the succeeding flowings are thought worth the saving, do not catch them in the graduate from which the solution was poured, but in some other, because so doing will cause air bubbles to form, which will be sure to cause trouble afterward. At the last flowing retain enough to flow back over the plate, and, keeping it in a level position put it into the "whirler," and whirl, at first with a slow motion, and gradually increasing in rapidity for a minute or so, when it should be examined for any specks or air-bubbles that may appear on the film. If there are any seen it is a misfortune; should they be air bubbles, they may be pricked with a needle, and in the after flowing they will disappear; but if they arise from dust the easiest way is to polish over again and begin from the bottom. These specks are sometimes unaccountably troublesome, and may result from acidity of the solution, so that it is well to prove it with litmus that it is in a neutral condition; if from air-bubbles, the best preventative is to keep the point of the funnel through which the solution is filtered resting on the bottom of the graduate; if they are from dust, it is obvious that the room requires sweeping out, or even the floor mopped and washed out, and to remember that cleanliness is an essential to success. If there are no such manifestations, flow again with the solution, and this time let the whirler be so arranged that a gentle heat may be applied, so it may be dried as quickly as possible. This may be conveniently done by holding the whirler over a gas stove, or other cleanly heat, and whirl in the same manner as before, which should take about three minutes. Care must be taken, however, not to expose to extreme heat—indeed the less the better—otherwise the albumen may become coagulated, in which condition it would not wash out in development. The plate may now be set aside to cool, and others coated and sensitized, or made ready for printing. Of course, the coating of the plate, it will be understood, is to be done in the dark-room, or with subdued light, and until time of printing set in a dark cupboard or other receptacle.

The Whirler.—The whirler may be of any form that will impart to the plate a rapid circular motion, the idea being to obtain by centrifugal action a perfectly equal distribution of the solution over the plate. Perhaps the simplest form of whirler we have ever known being used was that of a cord suspended over the stove, and twisted till the strain, on being relieved, gave the desired motion, on the principle of an old time cook's roasting jack. Such makeshifts, however, should only be resorted to by the genius who finds himself in a corner, and, nothing daunted, is determined never to stick. We give in the following diagrams the forms of two of the most frequently used. The working of the first will be readily understood from the drawing; that of the other we may describe as being made of hard wood, the long arms of thin hickory about 18x4¼ inch, around which is placed a broad rubber band. Being of such thin material the arms will spring out to suit almost all size plates within its capacity. The plate is held within grooves at the extreme end, or, what is better by small screws placed on the outer edge, the heads of which, holding the plate outside, allows the solution to flow uninterruptedly away under the motion. The diagram will explain how the motion is imparted, and it will also be seen that this form of whirler is very convenient for holding in the hand over the heat and at the same time whirled rapidly by the small handle at the upper end.

FIG. 378.—FORM OF WHIRLER, NO. 1.



The dotted line indicates the plate in position at A; B, the rubber band.

FIG. 379.—FORM OF WHIRLER, NO. 2.

Preparations for Printing.—The plate is now ready for printing. To this end let the thick plate glass of the printing frame be seen to as being thoroughly clean, also the negative. Frequently a moisture will collect on the glass of the negative. Frequently a moisture will collect on the glass of the negative, to obviate which let it be held over the gas stove for a few seconds.

As to the printing frame, it is scarcely necessary to describe it more than in a general way, that it is a square frame about four inches deep, in which is placed a piece of plate glass of from three quarters to an inch in thickness, of sufficient strength to withstand the pressure necessary to secure complete contact between the negative and the metal plate. This pressure is got from screws, as will be seen in Figs. 380 and 381. The frame must be purchased anyway, and its construction and working will be readily understood when practically examined.

Loading the Printing Frames.—Take the sensitized metal plate and rest on the points of the fingers of the left hand, and place the negative over it so as the picture will fall exactly in the center ; or lay the negative in the printing frame, film side up, and lay the sensitized plate over it. Let this be done gently and without moving about, so as to save any risk of abraiding the film of the negative. Turn over and convey to the printing frame ; place over them one or two pieces of felt; put on the cover, and proceed to screw down. This must be done very carefully so as not to break the negative. The safest way is to bring a gentle pressure to bear upon the centre screw, and on the others radiating from the center, and lastly on the corners,repeating this gently, always beginning at the center and going over the others until close contact between the negative and the plate is obtained.

FIG. 380.—PRINTING FRAME, CLOSED.

The Printing.—The plate is now ready for exposure, with a view to printing ; and here judgment and experience, the outcome of experiment, must be the best guide of the student. There are two elements on which he will have to bring his judgment to bear: first, the density of the negative, and, secondly, the intensity of the light. It may take anywhere from one to ten minutes. If a bright sun is out,and the negative of medium density, one minute may be ample, varying with a cloudy sky or a hazy atmosphere. A few practical experiments and the waste of a few plates will afford better lessons than any written words can convey, and knowledge will come as the reward of patient perseverance.

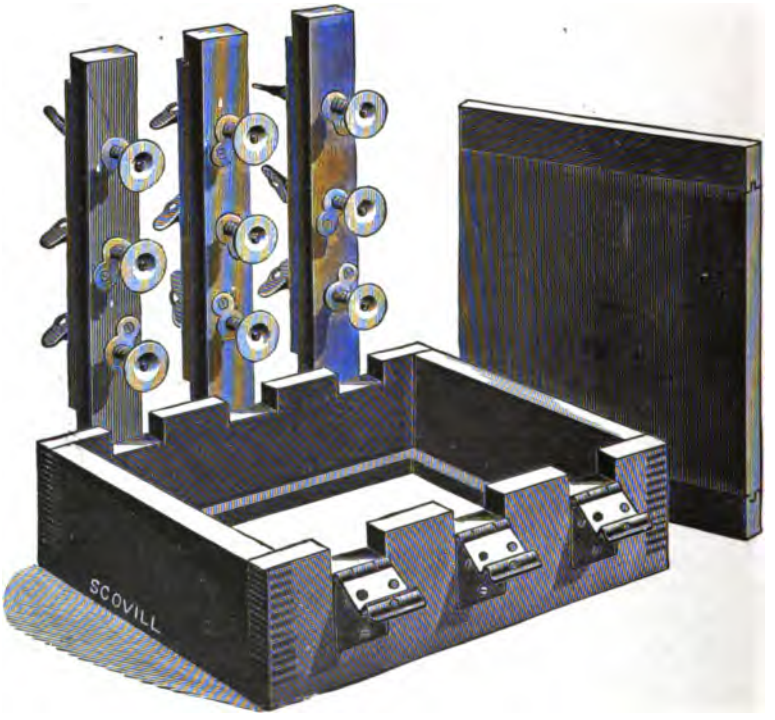


FIG. 381.—PRINTING FRAME, OPEN.

Development. — Having given what is deemed to be a sufficient exposure, remove the printing frame into the dark-room, unscrew and take out the plate, and place in a dish of slightly warm water, and rock for a few minutes. At this point it may be examined as to whether a correct exposure has been given. If so, the enameling solution will be found a little tough when raised by the finger-nail at any of the margins. If the time given has been too short, it will have washed away under the action of the water, especially when placed under the tap to wash out, which should now be done. If correctly timed it will stand considerable washing without injury. The effect will have been to wash out those parts of the solution which have been protected from the light by the denser portions of the negatives, and the half-tones in varying proportions.

Drying after Development.—Having been sufficiently washed, the drying may be accomplished by being set aside and allowed to dry spontaneously, or, as the manner of some is, to to reach the end more expeditiously, the plate may be flowed over with alcohol, and, held in tongs or pincers, a flame set to it, when it will be dried at once and be ready for the next operation, which is the burning in.

Burning In.—This operation is best performed over a small gas-stove, and requires a pair of large pincers, about twelve inches long, with broad point that will hold a good grip of the plate by the margin of the picture. It must be kept moving over the flame to and fro, so as to distribute the heat gradually and regularly over all the plate. In a few minutes it will be seen to change color and the picture to develop out more plainly. At this point it is safer to lay aside for a few minutes to partially cool, as a great heat too quickly brought to bear upon the enamel may cause it to crack ; meanwhile, other plates may be proceeded with and brought to the same stage. The burning should be continued until it assumes a rich deep brown, when it should be laid aside to cool gradually, when it is ready for the etching.

Corrections on Film.—Specks and other imperfections will now probably make their appearance, which had before been unsuspected, brought to light by the burning in of the enamel. The plate should, therefore, be examined under the magnifying glass and these corrected with a fine engraver. They will appear most injuriously in the high lights, and the remedy is to trim away the film between and so relieve the dots. This is rather a delicate operation and takes careful handling.

The Etching Fluid.—The etching fluid for copper is a solution of perchloride of iron. It is advisable to use it at full strength at first, gradually diluting. It is a curious fact that the strength of the solution is to a certain extent increased by the addition of water. Make up sufficient to cover the plate well but not so deeply as to prevent seeing its action in etching. A serious objection to using the fluid full strength is, that it is so opaque as to prevent the process of etching being observed and watched.

The Etching.—Pour the solution of chloride of iron into a shallow dish and insert the copper plate. The action of the iron will be at once seen in a change of color, resulting from the accumulation of sediment from corrosion. Brush this off with a soft camel's hair brush, and do so with a light circular motion rather than broad sweeps over the plate. Do so every half minute or so, when it is seen to accumulate over the plate. Occasionally blow the liquid from some part of the surface and keep a keen watch whether any of the dots show signs of etching away, when it must be at once stopped. Should the enamel give way too readily under the etching it was probably too acid, or the exposure under the printing frame had been too short, or the burning in not carried far enough. It may etch deep enough in five minutes to print well, but it is better, for giving greater ease in making ready at press and better printing results, to give a deeper etch, and if the enamel does not show signs of giving way, fifteen minutes may not be too long to give it. The progress and depth may be examined by the finger-nail upon the margin and stopped when it is judged far enough ; then taken out and brushed well with the camel's hair brush under the tap, then dried by gentle heat over the stove.

Enameling the Zinc.—Should zinc be the metal chosen to work with, nitric acid is employed in etching. Zinc plates, readily polished and prepared for engraving purposes, may be obtained, and it is greatly preferable to so purchase them than undertake the labor and trouble of polishing. It must, however, get a final polish with engravers' charcoal before flowing with the enamel solution ; and to eradicate any greasiness on the surface it may be placed for a few minutes in the lye used for cleaning the glass plates, and then given the final polish. The process of flowing the plate with the enamel solution is exactly similar to that described above for copper; but in burning in, the zinc, being a much softer metal, will not stand the amount of heat that copper does, and so the enamel cannot be burned to so deep a color, and, therefore, greater caution is required to burn to a degree sufficiently hard and yet not bring the zinc to the melting point.

Etching on Zinc.—A very weak solution of nitric acid is all that is necessary in etching halftone work on zinc. A solution of 1 drachm acid to 10 ounces of water, which will to taste be about the strength of vinegar, will be found right. It is usual to use a rocking tub, in which the plate is placed and the solution flowed over from end to end, while the oxidized zinc is gently brushed away ; it may be done quite as well, however, in a small porcelain or other flat dish as with the copper plate, and the same watchfulness of the film under the action of the acid must be exercised.

The Etching Tub.—The construction of the rocking tub for zinc etching will be readily understood by the following illustration of the latest and most improved form :

FIG. 382.—ETCHING TUB.

All that than remains is to mount the plate on wood to the height of type and take an impression from it on the printing press.

PROOF SPIRIT.—This term was originally employed to denote alcohol just strong enough to ignite gunpowder when poured over it and fired. A mixture of about equal parts of distilled water and absolute alcohol. It is defined by the Act 58 Geo. III., c. 28, to be "such as shall, at a temperature of 51° of Fahrenheit's thermometer, weigh exactly $\frac{12}{13}$ parts of an equal measure of distilled water."

Its specific gravity = ·9198 at 15°C., and it contains 49¼ per cent. by weight of absolute alcohol.

PROPENYL ALCOHOL.—See **Glycerine.**

PROTO-NITRATE OF IRON.—See **Ferrous Nitrate.**

PROTOCHLORIDE OF TIN.—See **Stannous Chloride.**

PROTO-SULPHATE OF IRON.—See **Ferrous Sulphate.**

PROTOXIDE OF LEAD.—See **Litharge.**

PRUSSIAN BLUE.—Ferrocyanide of iron. In the cyanotype process the image is formed in Prussian blue.

PRUSSIATE OF POTASH.—The red prussiate of potash is ferricyanide, and the yellow prussiate of potash is ferrocyanide of potassium.

PRUSSIC ACID.—Hydrocyanic acid.

PSYCHIC PHOTOGRAPHY.—See **Spirit Photography.**

PUMICE STONE.—A very porous rock of extreme lightness, chiefly exported from the Lipari Isles. It is a very useful substance. In the form of a powder it is used for polishing metals, woodwork, and for cleaning glass. It is also useful in removing stains from the fingers.

PUTREFACTION.—The apparently spontaneous decomposition of organic substances, especially those rich in nitrogen. It may be prevented (1) by keeping the substance in a vacuum; (2) by freeing from moisture and keeping perfectly dry; (3) by keeping in an atmosphere a few degrees below 0°C.; (4) by heating to boiling point and hermetically sealing; (5) by the use of antiseptics. According to Pasteur putrefaction only takes place when a substance comes in contact with living germs.

PYRO.—An abbreviated term for "Pyrogallol," or, as it is also termed, "Pyrogallic acid."

PYRO-AMMONIA DEVELOPER.—See **Developer.**

PYRO AND GLYCERINE DEVELOPER.—Edwards's formula is given under **Developer** as a pyrogallic developer for Isochromatic plates.

PYROCATECHIN (Formula, $C_6H_4(OH)_2$; synonyms, *catechol, oxyphenic acid, brenzcatechin, pyromorintannic acid*).—Obtained by the dry distillation of catechu extracted from the inner bark wood of the *Acacia catechu*, and also from *Kino*, another similar extract. The leaves of the Virginia creeper contain pyrocatechin. It is also obtained by fusing phenol-sulphonatic acid with caustic potash, and is present in crude pyroligneous acid, distilled from wood.

Pyrocatechin crystallizes in quadratic prisms soluble in water, alcohol, and ether. They fuse at 102° C, and boil at 245° C. In presence of alkalies it absorbs oxygen from the air, and becomes brown. Nitric acid oxidises it to oxalic acid. It is a reducing agent, and for this reason has been recommended as a developer for dry plates.

The first investigator was M. Benoist, who published his formula in *La Nature*, as follows:

SOLUTION A.

Distilled water	½ litre
Sodium sulphite	34 grammes
Pyrocatechin	8 grammes

SOLUTION B.

Distilled water	½ litre
Washing soda	75 grammes

Dr. Arnold's formula is as follows:

SOLUTION A.

Pure pyrocatechin	1 gramme
Water	100 c.cm.

SOLUTION B.

Sodium carbonate	20 grammes
Water	100 c.cm.

To develop a 10 x 8 plate take 1 c.c. of A solution and from five to ten c.c. of B in about 70 c.c. of water. For instantaneous drop-shutter work, more of solution A must be used.

Dr. Eder speaks highly of this developer, but notifies the importance of obtaining pure pyrocatechin. His formula is:

SOLUTION A.

Pyrocatechin	1 part
Sodium sulphite	4 parts
Water	40 parts

SOLUTION B.

Caustic potash	4 parts
Water	40 parts

For use, mix one volume of A with two volumes of B.

The advantages claimed for this developing agent are—freedom from fog, non-actinicity of solution, simplicity in preparation, high energy at low temperature, and a negative color that facilitates printing. According to Dr. Arnold, the plates lose their sensitiveness to light as soon as they are immersed in the developing solution, and may be developed at a distance of twenty inches from a gas flame, or in weak daylight. Further, the solution does not stain the fingers.

PYROGALLIC ACID.—A common but erroneous term for pyrogallol, which is not actually an acid. (See **Pyrogallol.**)

PYROGALLIC DEVELOPER.—Development with pyrogallol, or pyrogallic acid, as it is erroneously termed, in a solution with an alkali, is more general than with any other. One of the chief advantages with this form of developer is the power of the operator possesses of varying it to suit the requirements of the subject. Greater latitude of exposure is also possible with this developer than any other. Pyrogallol is usually kept in the solid state, preventing decomposition, but if required in solution it can be dissolved in a solution of sodium sulphite, slightly acidified with citric acid, and of such strength that the solution contains ten per cent. of pyrogallol. The darkening of the solution is thus prevented, as the sodium sulphite suffers oxidation instead of the pyrogallic acid.

Strong liquid ammonia, specific gravity .880, is mixed with nine times its bulk of water, so that every ten minims contains one minim of the ammonia. The potassium or ammonium bromide should also be made up as a ten per cent. solution. Sodium carbonate, if used, should be purchased in the dry state, and made up in a ten per cent. solution. Potassium carbonate should also be purchased dry, and can be made up into solution as strong as 50 per cent. if required. In making up these solutions the water must not be measured out but added to the solid until the solution measures ten times the weight of the solid used.

Sodium sulphite is usually made up as a 20 per cent. solution.

The pyro developer can be made up after hundreds of different formulæ. Every maker of plates usually recommends a certain one, and it is generally advisable to give this a trial for that kind of plate. These formulæ vary very considerably; for instance, one manufacturer of plates recommends

Pyro	Potassium bromide	Ammonia
6	¾	5

and another

Pyro	Potassium bromide	Ammonia
3	7	12

The following is a table of the largest and smallest quantities of chemicals admitted to the pyro developer:

	Largest.	Smallest.
Pyro per ounce	10 grains	11.4 grains
Sodium sulphite	80 grains	5 grains
Sodium carbonate	40 grains	11.5 grains
Potassium carbonate	21 22.10	5 grains

For various formulæ for pyrogallic development, see **Developer.**

PYROGALLIN.—See **Pyrogallol.**

PYROGALLOL (derived from gallic acid and heat). Formula, $C_6H_6O_3$; molecular weight, 126; synonyms, *trihydroxybenzene, pyrogallic acid, pyrogallin, pyro.*—A trihydroxybenzene derived from gallic acid by destructive distillation, carbon dioxide being given off as one of the products of decomposition, thus:

$$C_6H_2(OH)_3.CO_2H=C_6H_3(OH_2)+CO_2.$$

It is prepared as follows: Gallic acid dried at 100 deg. C. is mixed with three times its weight of powdered pumice stone to equalize the heat, and distilled in a retort, through which a slow

stream of CO_2 is passed, the retort being heated by an oil-bath between 210 deg. and 220 deg. C. A solution of pyrogallol, for use as a developer for photographic purposes, can readily be prepared by heating ten grammes of gallic acid with 30 c.c. of glycerine to 195 deg. C, so long as carbon dioxide is evolved. It is then made up with water to one litre. Of course, by this method the pyrogallol is obtained mixed with glycerine.

Pyrogallol crystallizes in fine needles felted together in light white tufts. It fuses at 115°C., and boils at 210°C. It is very soluble in water (1 in 2½ parts) and in alcohol and ether, and is more or less poisonous. Metagallic acid is sometimes present in samples of pyro, which have consequently a slightly brownish color, and leave a residue when dissolved in water.

If the solution be mixed with an alkali it absorbs oxygen from the air, turning brownish-black, and forming carbonates, acetates, and other products, a small quantity of carbon dioxide being evolved. It is a most powerful deoxidizer and reducing agent. Its action upon the silver salts causes it to be most extensively used as a developing agent. The reducing power of an alkaline solution of pyrogallol is in fact so great that it cannot be used alone, as the whole plate would be reduced, and we should get what is termed "fog." For this reason, therefore, a restrainer is added. The best for this purpose is a soluble bromide such as that of potassium.

Owing to the rapid oxidizing properties of pyrogallol solution it is very difficult to preserve. All of the following substances have been recommended for the purpose:—Formic acid, glycerine and alcohol, potassium metabisulphite, sodium sulphite, and citric acid.

PYROGENTISIC ACID.—See **Hydroquinone.**

PYROLIGNEOUS ACID.—An impure form of acetic acid obtained by the destructive distillation of wood.

PYROQUINOL—See **Hydroquinone.**

PYRO-STAINS.—Pyro-stains may be removed from the fingers by washing in a ten per cent. solution of oxalic acid or sulphuric acid diluted with water in the proportion 1 to 20, or a mixture of bleaching lime and citric acid.

PYRO-TABLETS.—Pyrogallol is sold in this form for the convenience of tourists. The pyro is compressed into tablets or cakes, each of which is scored into twenty-five 4-grain divisions which may be easily separated.

PYROXYLIC SPIRIT.—See **Alcohol Methylic.**

PYROXYLIN (Formula $C_6H_5(NO_2)_2.O_5$; molecular weight, 252; synonyms, *pyroxyline*, *dinitro-cellulose*, *gun cotton*). This name is applied to a series of compounds obtained by acting on vegetable fibres with nitric and sulphuric acids. They are all more or less explosive, and are all what are termed substitution compounds, being derived from the vegetable fibre by the substitution of atoms of NO^2 for an equal number of atoms of H in the fibre. The pyroxylin with which we have to deal with here is that known as the soluble kind, sometimes termed collodion wool, as is used in the manufacture of collodion for photographic purposes.

It can be purchased ready for use, and it is advisable to obtain it in this form, as its manufacture is attended with considerable danger.

The following directions are for preparing pyroxyline.*

The most important part is the composition of the nitric-sulphuric acid in which the pyroxyline is prepared, as the slighest variation in the quantity of water, in the relative proportions of the two constituent acids, or in the temperature at the time of putting in the cotton, will effect the result.

Sulphuric acid sp. gr. 1.854 at 60°F	18	fluid ounces
Nitric acid sp. gr. 1.45 at 60°F	6	fluid ounces
Distilled water	4½	fluid ounces

The water is poured into a dish, and the nitric and sulphuric acids added in the order written.

The mixture is then well stirred, and the temperature, which will have considerably increased on addition of the sulphuric acid, must be allowed to sink to 150° Fahr., and at this temperature it must be kept by means of a water-bath. The wool is first immersed in a strong solution of sodium or potassium carbonate to free it from the natural oil contained in it, and then well washed in clean water until the latter shows no trace of alkalinity or the salt used. It is then dried. The wool prepared in this manner should be weighed out in balls of about thirty grains each, and these are immersed one by one into the acid mixture, and well stirred in it, so that each ball becomes thoroughly saturated with the acids. They are then left for ten minutes and removed and washed in a running stream of water for twenty-four hours, or until they give no acid reaction when tested with litmus. They are then dried in the sun or on a water-bath. When dry they form the collodion wool of commerce, and should be entirely soluble in a mixture of equal parts of alcohol and ether. They should also be inflammable. The nitric is the only acid that acts upon the cotton wool, the sulphuric merely increases the rapidity of its action.

* Hardwich's Photographic Chemistry.

Pyroxyline can be made from many varieties of cellulose. Cotton, straw, pith, flax, linen, calico, have all been used, giving more or less different results However, cotton wool is the substance generally employed, and sea islands cotton is generally preferred. Schering's celloidin is a very pure variety of coliodion cotton. It occurs in horny faintly yellow masses, soluble in alcohol and ether and giving a very fine collodion, producing an even and structureless film.

Pyroxyline is insoluble in water, alcohol or ether alone, but is soluble in a mixture of the two latter, forming collodion.

Hardwich says that the temperature of the nitro-sulphuric acid at the time of immersing the cotton invariably affects the photographic properties of pyroxyline. At high temperatures a portion of the film is converted into a substance which has a bitter taste, and turns brown when treated with alkalies. This substance is believed to be nitro-glucose, formed by the action of strong nitric acid upon grape sugar; the grape sugar itself being prodnced by the cellulose by contact with the warm and diluted sulphuric acid. Its presence in the collodion tends to diminish the sensitiveness of the film to weak rays of light, but increases the rapidity and intensity of the development in negative images

Pyroxyline is liable to decomposition, a partial liberation of oxides of nitrogen apparently taking place, forming in some cases, red fumes within the bottle. It can be kept perfectly, however, if the following precautions are taken: First, it should be thoroughly washed and thoroughly dried; and, secondly, it should be kept in a well-ventilated vessel—a thin cotton bag, in which it can be loosely stowed away is a good receptacle. It is dangerous to press it too tight in a stoppered bottle. Light, heat and moisture are all agents facilitating decomposition, it should therefore be kept in a dark, dry and cool place.

Papyroxyline.—Liesegang was probably the first to introduce this substance for collodion making. It is a kind of pyroxyline made from paper instead of from cotton wool. The following is a formula for washed emulsion processes:—

Nitric acid sp. g. 1·45	2 fluid ounces.
Sulphuric acid sp. g. 1 845	3 fluid ounces.
White blotting paper*	145 grains.

The temperature should be about 100 degs. Fahrenheit and the time of immersion about half an hour.

QUALITATIVE ANALYSIS.—See **Analysis.**

QUANTITATIVE ANALYSIS.—See **Analysis.**

QUART.—The fourth part of gallon; two pints, or 69·3185 cubic inches.

QUARTER-PLATE.—The size of dry plate, 3¼ x 4¼ inches.

QUICKLIME.—See **Calcium Oxide.**

QUINOL.—The same as **Hodroquinone** (*q.v.*)

QUINOL DEVELOPER.—See **Hydroquinone.**

QUINOLIN, RED (Formula, $C_{26}H_{19}N_2Cl$).—Occurs either in the form of a deep crimson, powder or in reddish-brown prisms It is only slightly soluble in water, but soluble in alcohol, forming a solution having a reddish-yellow fluorescence. It occurs mixed with cyanin blue in commercial azalin, used in orthochromatic work.†

QUINTAL.—A measure in weight according to the metric system. It is equivalent to 220·46 lbs. avoirdupois.

RACK AND PINION.—A contrivance for producing a limited rectilinear motion from a circular one. A tooted wheel or pinion rotating about its own axis is caused to work in a straight or toothed bar. This contrivance is often attached to the focusing arrangement of the camera By simply turning a screw or small handle the distance between the lens and the focusing scene can be adjusted at will.

RACKS.—Contrivances, usually of wood or metal, used for drying or draining plates. Those made to fold up are the most convenient for use.

FIG. 383.—DRYING RACK.

RADICAL.—The basis of a compound. Gerhardt's definition is, "the proportion in which certain elements or groups of elements may be substituted for others, or may be transferred from one body to another in the act of double decomposition."

RADICAL COMPOUND.—In organic chemistry a compound radical is a group of elements which, in the various changes and decompositions which a substance undergoes, remains unaffected, and acts as if it were an element. Cyanogen, ethyl, etc., are compound radicals.

*Papier Josef or Swedish filtering paper is a pure form that can be used for this purpose.
†C. J. Leaper.

RAIN WATER.—See **Water.**

RAPIDITY.—The rapidity of a lens is dependent upon the relation the focus bears to the working aperture. The rapidity of the photographic dry plate is usually known by its sensitometer number, but this is often very misleading, however. The rapidity is usually obtained by heating the bromide emulsion for some time or by the ammonia process.

RAPID LENS.—Any lens allowing a large quantity of light rays to pass through upon the sensitive plate. The rapidity of a lens is dependent upon the relation the focus bears to the size of working aperture. Depth of focus and definition are opposed to rapidity, and, therefore, any arrangement tending to increase the depth and definition can only be made at the expense of rapidity. It is generally understood that the rapidity of all lenses is equal with the same ratio size diaphragm. Although this system holds good with single lenses, through which the same amount of light is always admitted through the same size aperture of diaphragm, yet with combinations of two lenses, a certain distance apart, as in rapid rectilinear, etc., this cannot be said to be quite correct. Here the ratio of the focus to the actual aperture no longer regulates the rapidity. The available aperture (A) is in this case given by the equation $A = \frac{fa}{f-d}$, f being the the focal length, a the actual aperture of the diaphragm, and d the distance between the center of the diaphragm and the nodal point of emission of the back combination.

RAPID RECTILINEAR.—A rapid lens corrected for aberration, and giving straight lines when photographing buildings or other similar objects.

RASTER PLATE.—See **Line Screen.**

RAY.—A line of light proceeding from a radiant point or a point of reflection. A collection of rays is termed a pencil. An incident ray entering a doubly refracting crystal is resolved into two; termed from their properties an ordinary and an extra-ordinary ray.

The term ray is also applied to one of the component elements of light, as the violet rays of the spectrum, or the luminous actinic or heat rays.

Visual Ray.—In perspective, a straight line drawn through the eye.

REACTION.—A chemical termed applied to the change or effect produced by bringing two or more elements or compounds together, whereby one or more new bodies are formed.

READY-SENSITIZED PAPER.—Albumenized paper can be purchased ready sensitized. It keeps for about four to six months. Although now made of very good quality the results obtained upon it are never so good as upon paper freshly sensitized without the addition of the preservative necessary with commercial sensitized paper. Ready-sensitized paper can be purchased either in sheets or in cut sizes. The sizes of the sheets are as follow: 18 x 22¾, 20½ x 24½, 22 x 36, 26 x 40, 27 x 42. The paper should be carefully protected from light and from moisture. Packets of cut sizes are better kept under heavy pressure. This not only keeps the paper flat, but also forces out the air from between the sheets and retards its discolorlng action.

REAGENT.—A term in chemistry applied to any substance employed to bring about a chemical reaction or change in another element or compound, with the view, generally of either detecting its presence or effecting its separation from other substances.

REAL IMAGE.—See **Optics.**

REAM.—A quantity paper of any dimensions containing twenty quires of twenty-four sheets, or 480 sheets in all. It is a common practice to count 500 sheets in a ream, though with prepared papers this is rarely done.

REAUMUR SCALE.— See **Thermometer.**

RECOVERY OF WASTE.—See **Residues.**

RE-CRYSTALLIZE.—To crystallize again or anew.

RECTIFICATION.—The concentration of a volatile substance by distillation, as when spirits of wine is prepared from a dilute solution of alcohol by repeated distillation.

RECTIFIED SPIRIT.—Alcohol, with sixteen per cent. of water. Sp. gr. 0·838; strength, 56 over proof.

RECTIGRAPH.—A name given to a class of corrected lenses.

RECTILINEAR.—A term applied to lenses which have been corrected for aberration as much as possible, so that in photographing architectural subjects the lines appear perfectly straight in the image.

RED CHROMATE OF POTASH.—See **Potassium Dichromate.**

RE-DEVELOPMENT.—A process formerly adopted with wet collodion. It is in reality intensification of the image, and has been recommended for bromide plates and paper. The negative or print, after thorough washing, is bleached in a solution of cupric or mercuric chloride, and then re-developed with ferrous oxalate or hydroquinone. For bromide paper dilute ferrous citrate developer acts well.

RED FOG.—See under **Fog.**

RED LIGHT.—See **Non-actinic Media.**

RED PRINTS.—Red prints may be obtained by the following process:

Citric acid	100 grains.
Ammonium chloride	100 grains.
Gelatine	10 grains.
Water	10 ounces.

Dissolved the citric acid in a small portion of water, and exactly neutralize with sodium carbonate. Float the paper on this bath for one or two minutes, and sensitize upon a fifty-grain nitrate of silver solution. Fix in fresh hypo without toning.

Another process.* In a small quantity of water mix 72 grammes of nitrate of uranium and 20 grammes of nitrate of copper, then neutraiize the solution with a little carbonate of soda, and add water to measure one litre. Sized paper is floated for a minute or two on this solution and dried in the dark. Print until image is fairly visible. Develop with an eight per cent. solution of potassium ferricyanide until the required density is obtained. Fix by well washing; or

Immerse a well fixed and washed bromide print into a 15 per cent. solution chloride of copper. The picture is converted into chloride of silver and apparently disappears entirely. After careful washing all the copper must be removed; it is then put for a few seconds in a 5 per cent. bath of ferrocyanide of potassium, washed again, and then transferred to a 2 per cent. bath of copper chloride, when the picture will reappear with a blood red color.

This is one of the best methods of making red photographs, but washing thoroughly after every operation is essential.

RED PRUSSIATE OF POTASH.—See **Potassium Ferridcyanide.**

REDUCING.—When a negative has been over-developed, and becomes too dense, it require. a considerable time printing the positive images. In order to save this it can be reduced. It also happens very often that the plate is under-exposed, and in forcing out the details in the shadows the high-lights become too dense. Here reduction is also advisable sometimes. The action of the solution, however, begins on the surface of the film, and works its way through, consequently, unless the solution be made very weak, it will in all probability dissolve away the shadow details before accomplishing the required reduction in the darker parts of the negative.

With ferrous-oxalate developer reduction in density can often be accomplised by immersing the developed negative in the hypo bath without previously washing. If this has not a sufficient effect a mixture of one part of the ferrous oxalate developing solution and one part of the fixing solution acts as a powerful reducer. Clearing solutions usually have a slight reducing action upon the negative. A method often practiced, although by no means advisable, consists in bleaching the image in a saturated solution of mercuric chloride. Usually, however, the change in color from black to white causes too great a diminution in opacity, and, further, the bleached image will usually change when exposed to the light in printing.

There are a number of formulæ for reducing the image by dissolving it partially away Among these may be mentioned the following:

FARMER'S REDUCING SOLUTION.

Sat. sol. potassium ferridcyanide	1 part
Sodium hyposulphite solution (1 in 5)	10 parts

BELITZKI'S REDUCER FOR GELATINE PLATES.

Water	7 ounces
Potassium ferric oxalate	2½ drachms
Crystallized neutral sodium sulphite	2 drachms
Powdered oxalic acid	30 to 45 grains
Sodium hyposulphite	1½ ounce

The solution should be made up with the ingredients added in the same order as written. It is then filtered and kept in well-corked bottles in subdued light, the influence of light being to reduce the ferric salt to ferrous. Ottomar Jarecki has suggested a modification of this reducer. His formula is as follows:

*M. Letellier in *Revue Photographique.*

Water	7 fluid ounces
Sol. chloride of iron	2 fluid drachms
Potassium oxalate	3 drachms
Sodium sulphite, cryst	2 drachms
Oxalic acid, about	35 grains
Sodium hyposulphite	1½ ounces, av.

The solids are powdered and the chemicals are added in the above order, dissolving one before adding the next. The color reactions that take place are an amber color when the iron solution is mixed with the water, an emerald green on adding the neutral oxalate of potassium; a ruby red with the sulphite of soda, and the original green restored on dissolving the oxalic acid; in fact, the oxalic acid is added little by little until this green color appears, and at the same time the smell of sulphurous acid is perceptible. The color remains the same after addition of the hypo. It is desirable to filter finally.

BARTLETT'S REDUCER.

Perchloride of iron	30 grains
Citric acid	60 grains
Water	1 pint

DICHROMATE REDUCER.

Potassium dichromate	20 grains
Hydrochloric acid	10 minims
Water	1 ounce

EDER'S REDUCER.

SOLUTION 1.

Ferric chloride	1 part
Water	8 parts

SOLUTION 2.

Potassium oxalate	2 parts
Water	8 parts

Equal parts of each solution are mixed before using, and a small quantity of the mixture added to a strong solution of hypo. The plate is then immersed, or the solution applied locally, and the image rapidly weakens. The chemical action of the reducer is to convert the silver of the image into oxalate of silver, which is immediately dissolved by the sodium hyposulphite.

Local reduction is a term applied to the reduction of certain portions of the negative only. This is done when the film is quite dry by rubbing it with a soft pad moistened with alcohol until the density is reduced as required. The pad is usually composed of a tuft of cotton-wool or a piece of wash-leather, flannel, etc. For sharply-defined outlines, a pointed stick of soft wood is used steeped in alcohol.

The above remarks all apply to the reduction of gelatino-bromide dry plates. Prints upon bromide paper may also be treated in the same manner.

Prints upon albumenized paper which have been over-printed can be reduced by immersion in a solution of cupric chloride, or before toning, by using platinic chloride in place of the gold salt.

Prints on collodion paper can be reduced by immersion in a very strong solution of hyposulphite of soda before placing in the combined toning and fixing baths.

Cyanotype or ferro-prussiate prints can be reduced by immersion in a weak solution of ammonia, and afterwards into a weak solution of hydrochloric acid.

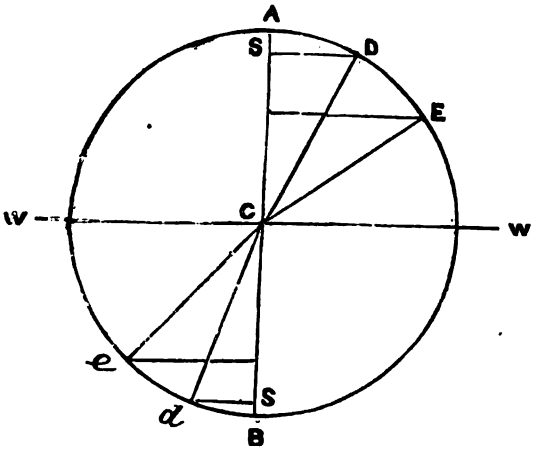


FIG. 384.

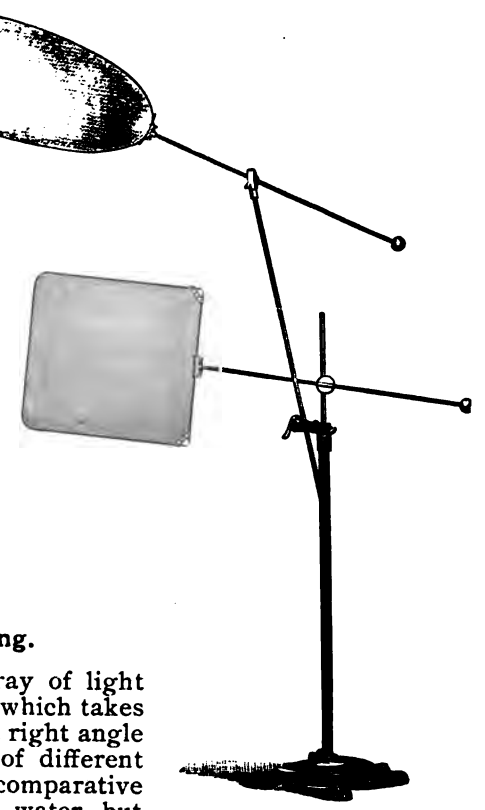
REDUCING AGENTS.—In chemistry this term is applied to bodies which have an action the inverse of oxidation, such as nascent hydrogen from sodium amalgam, zinc, etc.

The term is also applied in photography to those agents usually termed developers, which, by their reducing action upon the exposed silver salts, cause the latent image to become visible.

The same term is also given to certain compounds or solutions of compounds which will reduce the opacity of an over-dense negative.

REDUCTION (*in size*) —The operation of producing transparencies or prints from negatives of large dimensions. The opposite to enlarging. The negative to be reduced is inserted in the

same position as for enlarging. The lens, however, is turned towards the negative and the image focused on the ground glass screen. The distances will be found on reference to the table of conjugate foci on page 135. In reducing, the greater distance must, of course, be between the lens and the negative, and the lesser between the lens and the sensitive film.



(FIG. 385.)—REFLECTING SCREEN.

REFLECTING CAMERA.—A camera made in the form of a camera obscura, so that the image upon the ground glass appears the right way up. A mirror inside at an angle with the lens produces an image on the ground glass at the top. When ready for exposure the mirror is lifted up, making the interior light-tight. The dark slide forms the back of the camera, and is always in position ready for use.

REFLECTING SCREEN.—A screen used for reflecting the light upon the sitter in portraiture (Fig. 385.)

REFLECTION.—See under **Optics.**

REFLECTORS.—See under **Optics.**

REFLECTORS, SILVERING.—See **Mirror, Silvering.**

REFRACTION.—The bending or deflection of a ray of light (including heat and all other forms of radiant energy) which takes place whenever the ray passes at any other angle than a right angle from the surface of one medium into another medium of different density. This optical density by no means coincides with comparative specific gravity, *e. g.*, turpentine is optically denser than water, but floats on the top of it. It is a retarding influence, and accordingly when the ray enters the denser medium at right angles, though not refracted, it is retarded in a certain proportion, traversing a less distance in a given time. Rays at other angles, it can be shown by analysis, must be bent aside according to a law discovered by Snell, about A.D. 1620. Let W W (fig. 384) represent the refracting surface of the denser medium—for example, water; and draw A B perpendicular to that surface. Describe a circle round the point C where the perpendicular cuts the surface. Now let a ray, D C, enter the surface at C, at some angle A C D with the perpendicular, and suppose it is found by experiment that the refracted ray takes the direction C d. In the first place the refracted ray will be found to be in the same plane as the incident ray. In the second place, if the medium below W W be the denser, the refracted ray will be bent towards the perpendicular, and the reverse in the contrary case, so that a ray, d c incident in water, would be refracted as C D, further away from the perpendicular on emergence into air. But thirdly, the refracted course of every other ray can now be calculated according to the following law. Draw D S and d s normal to the perpendicular, then the lines D S and d s will represent, geometrically, the sines of the arcs A D and d B, and if the radius C A be unity, the numbers expressing S D and d s will be sines of the angles. The sine S D will have a certain ratio to the sine d s. And now if any other incident ray (E C) be taken, its sine found in the same way will be found to bear the same ratio to the sine of the refracted ray. This ratio of the sines is therefore invariable for all incidences for the same homogeneous substance. Such ratio is called its refractive index, and it will be readily seen how the index of any substance, as some kind of optical glass, being once found by simple experiment, the course of every refracted ray incident at any angle on the curved surface can be foreseen, and thus its focus or other properties calculated, or the curves calculated for a given focus, which is simply the point to which refracted rays converge.*

Double Refraction.—Many crystals are not homogeneous, but have different properties of elasticity, etc., in different directions. The effect of such a constitution is that, unless a ray of light enters the crystal in some particular directions, it is not merely refracted in the manner described under refraction, but diverted into two rays. In this case the refracted ray or rays are not always in the same plane as the incident ray.

Plane of Refraction is the plane passing through the normal or perpendicular to the refracting surface at the point of incidence and the refracted ray.

REFRACTIVE INDEX or **INDEX OF REFRACTION.**—When a ray of light passes obliquely from a rare to a dense medium it is refracted to a certain extent, varying with the medium

* Hunter's "Encyclopedia."

employed, as the sine of the angle of incidence always bears an invariable ratio to that of the angle of refraction, for the same ray and the same medium. This ratio is termed the refractive index of that medium.

The following table gives the refractive indices of a few well known substances :—

Gas.	Index of refraction.
Air	1·000294
Oxygen	1·000272
Hydrogen	1·000138

Liquid.	Index of refraction for mean yellow ray.
Linseed oil	1·485
Oil of turpentine	1·457
Alcohol	1·372
Ether	1·358
Water	1·336
Glycerine	1·470

Solid	Index of refraction for mean yellow ray.
Diamond	2.47 to 2.75
Sulphur	2.115
Flint glass	1.575
Rock crystal	1.547
Canada balsam	1.532
Crown glass	1.525 to 1.534
Plate glass	1 514
Iceland spar	1.654
Ice	1.315

REFRANGIBILITY.—The property which rays of light possess of being bent out of a straight line when they pass from one medium to another of different density.

RE-GILDING.—Photographic picture frames may be re-gilt after the following method given in "Spon's Workshop Recipes": —Wash the frame well with a sponge and clean water, and when dry give it two coats of water-gold size mixed with some warm thin size from dry hide or parchment. When dry rub over with fine sand-paper, and it is then ready for gilding with the gold leaf. After acouple of days it can be finished with an agate burnisher.

REGISTER.—The register of a camera is the correspondence in position between the focusing screen and the surface of the sensitive plate or film afterwards introduced. This, especially where lenses of large aperture are used, should be very carefully tested. The most effective method of doing this is by focusing a distant object, such as a signboard with sharply defined letters on it, using the full aperture of a rapid lens. A focusing glass should be employed if the operator does not possess good eyesight. The focusing screen is then removed, and each side of the different double plate-holders is brought into position, having a piece of ground glass fitted where the dry plate is usually placed. The two slides are then withdrawn, and the image examined. If perfectly sharp the register is correct. Another method is to expose a plate and examine for sharpness, but this is also a test for chromatic aberration in the lens.

REGISTERING COPYRIGHT.—See **Copyright.**

RELIEF.—A photo relief is an image in which certain portions stand out higher than others. In carbon and Woodburytype prints the image is in relief, although very slightly. The simplest method of making a relief is described under **Woodburytype.** A relief may be obtained on an ordinary fairly thickly-coated gelatine dry plate. Give a rather full exposure, and develop with—

A.—Potassium hydrate stick	180 grains
Sodium sulphite	180 grains
Water	3 ounces
B.—Pyro	48 grains
Water	8 ounces
C.—Potassium bromide	60 grains
Water	1 ounce

Six drachms of B are mixed with two drachms of A, and the plate immersed until all the detail is produced. Ten drops of C are then added, and development continued until sufficient density is obtained. After development, the plate is well washed and immersed in a 10 per cent. solution of chrome-alum, warmed to about 30 to 40 deg. C., gently brushing it while in the solution with a soft brush. By this means a negative in relief can be made.

REMBRANDT EFFECT.—This name is given to a style of portraiture in which the shaded side of the sitter is portrayed with light more or less behind the head, and intended to resemble the great works of the celebrated artist of that name.

REMOVAL OF FILM.—The gelatine films may be removed from the glass plate by immersing them in a weak solution of hydrochloric acid. M. L. Mather recommends the fluorides of sodium and potassium for stripping the films from the glass plate. These alkaline fluorides, when in the presence of an energetic acid, such as sulphuric acid, liberate a small quantity of hydrofluoric acid. He first places the negative in a solution of the alkaline fluorides mentioned, for say three or four minutes, and then without washing immerses it in a 10 per cent. solution of sulphuric acid. A trace of hydrofluoric acid is thus produced in the film and the latter gradually detaches itself. To prevent expansion the negative should be previously soaked in a strong solution of chrome-alum and then well washed. The films on old and useless negatives are best soaked for some time in cold, and afterwards in hot water. They are then well rubbed with whiting. Wall recommends rubbing them with a paste composed of pumice-stone powder and glacial acetic acid.

REPEATING BACK.—A form of single plate-holder so arranged that two separate negatives may be made upon one plate. There are many forms of studio cameras with repeating backs, enabling the operator to take two cabinet or c.-de-v. pictures upon one plate. Repeating backs are also used for single stereoscopic cameras, with one lens only, the two negatives being made upon the one plate, the lens having been moved about two inches previous to making the second exposure.

RESIDUES.—The recovery of the unused gold, silver, and platinum used in photography is now practised by all who use large quantities.

Silver Residues.—It is well known that only about three per cent. of the silver used in sensitizing albumen paper remains in the finished prints; although it is not possible to recover the whole of the remaining 97 per cent., yet by careful practice about 80 per cent. should be saved. The following table, showing where the different losses take place, has been carefully compiled by MM. Davanne and Girard:

	Silver per cent.
Draining papers	1·028
First and second washing waters	52·860
Hypo bath	32·100
Washing water of fixed proofs	4·110
Cuttings and clippings	4·570
Remaining on proofs	3·100
Loss	2,232
	100·000

It will be observable that the greater portion of the silver is to be found in the first washing waters and in the hypo bath—nearly 85 per cent., so that it will well repay one to save these, if only a fair portion of the silver can be extracted.

Residues may be divided into three classes, *i. e.*:—

1. Clippings, cuttings, spoilt paper and prints.
2. Washing water used previous to fixing.
3. Old hypo baths.

Unless large quantities of paper are used, the first-class can be entirely abandoned if the unreduced silver is fixed out from the spoilt prints, etc. If they are saved, however, they should be stored away until a good quantity is obtained. They are then made into a pile, and burnt by setting fire to the top of the pile and allowing it to descend. The ashes are then collected and sent to the refiners, or, instead of burning, the paper may be beaten up to a pulp, with dilute sulphuric acid and strips of metallic zinc or copper placed in the mixture. Metallic silver is precipitated, and the zinc or copper is dissolved.

With regard to the second class of residues, the first and second washing waters only should be saved in a large tank or tub, and hydrochloric acid or common salt added, and the liquid allowed to settle. When the top is quite clear, the silver chloride will have settled to the bottom, and the liquid decanted or syphoned off. When a fairly good portion of the silver chloride is obtained, it should be collected, dried, and sent to the refiners.

The third class, *i. e.*, the old hypo bath, cannot, of course, be subjected to the same treatment, as the silver chloride is soluble in them, and would not precipitate. To reduce the silver from the fixing baths, the old solutions are kept separately in a tub or earthenware vessel, and some sulphuretted potash (liver of sulphur) added, which throws down the silver as a black deposit of sulphide Ag_2S. In this state it should be sent to the refiners. It can be reduced to metallic silver by roasting to free it from the the sulphur, and fusing. There are serious draw-

backs to this process, however. The stench is abominable and injurious, and if free sulphur be left in, explosions are likely to occur when the mass is fused.

Davanne's method of recovering the silver from old hypo baths consists simply in immersing a plate of copper in the hypo bath, and letting it stand for about four days. The silver becomes gradually deposited upon the copper plate, whilst the copper is dissolved in the liquid. The copper plates are generally stood up on end against the sides of the tub, and are occasionally brushed with a stiff brush. The metallic silver will then settle gradually to the bottom, and when a sufficient quantity has accumulated it is filtered and washed. The filtrate, consisting of metallic silver and a little copper, can easily be converted into silver nitrate, slightly blue owing to the copper. If only a small portion of copper be present it will have no injurious effect; if a large quantity is detected, it can be thrown down as an oxide in the form of a black powder. The silver oxide should be added until the blue color has disappeared.

Instead of sending the residues to the refiners they can be all mixed together with nitrate of potash and charcoal, and fused in a crucible.

The silver bromide from old waste emulsion can be recovered by first melting and then adding a small quantity of hydrochloric acid, and boiling for a few minutes. The gelatine is thus destroyed, and is poured off, the precipitated silver bromide is then collected, and can be placed among the other residues.

The following processes* of recovering silvering waste may also be found useful:

I. *Photographers' Waste Bath.*—(1) Add solution of caustic potash or lime, as long as there is a brown precipitate; allow it to settle; pour off the liquid and collect silver oxide for reduction. See III.

(2) For 1 pound of silver add 1 ounce of sulphuric acid and one half pound zinc and allow it to stand two days. Precipitate as a chloride, wash eight or ten times by decantation, and dissolve gradually in nitric acid. Test the complete washing by hydrochloric acid. Wash with water till the zinc nitrate is removed. If zinc clings to silver, wash with hydrochloric acid.

(3) Suspend a sheet of copper in bath for two or three days.

(4) Acidify with nitric acid, precipitate as silver chloride by sodium chloride or hydrochloric acid, and reduce as III.

(5) Immerse in bath two strips of copper attached to a Daniell's battery. Silver deposited on the copper as in No. 3.

(6) Add sodium carbonate or hydrate. Reduce as in III. below, or, if pure enough, dissolve the precipitate at once in nitric acid.

(7) Concentrate bath made alkaline by sodium carbonate and add aqueous solution of oxalic acid neutralized with sodium carbonate. Filter, dry, and fuse with equal weight of sodium carbonate.

(8) Deposit either with or without a battery on iron. Fuse with potassium nitrate and sodium carbonate.

II. *Hyposulphite Bath.*—(1) Precipitate as silver sulphide by potassium sulphide. Reduce as III., or dissolve in nitric acid.

(2) Precipitate with hydrosulphuric acid and reduce as III.

(3) Decompose the hyposulphite by waste nitrosulphuric acid from manufacture of gun-cotton for collodion. Have silver sulphide and sulphur with sodium nitrate and sulphate in solution. Suspend zinc in the solution, then boil two or three hours; wash and filter, dry, fuse with borax and sodium carbonate.

(4) Suspend sheet copper in the solution

(5) Add hydrochloric acid, which sets free sulphur and precipitates silver chloride. Oxidize the silver by aqua regia and reduce silver chloride as in III.

(6) Add sodium hypochlorite to the alkaline solution. Wash precipitate, and fuse with mixed carbonates. This gives no fumes of sulphur. Sodium bisulphite and chlorides are by-products.

III. *Reduction of Silver Chloride, Oxide or Sulphide.*—(1) Mix with one-third its weight of colophony. Heat moderately in a crucible till greenish-blue flame ceases, then suddenly increase the heat, when a button of the metal is obtained.

(2) Melt with alkaline carbonates enough to cover surface from air; then mix with 75 per cent. chalk and 4 per cent. charcoal and heat.

(3) Ignite with nitre on red-hot plate, carefully, and in small quantities to avoid explosions, run down to a bead with sodium carbonate and borax.

(4) If a chloride, reduce to an oxide by boiling with strong potash, then reduce by glucose, or boil the chloride with glucose and sodium carbonate.

(5) Add silver chloride dissolved in ammonia to a boiling solution of 1 part glucose and 3 parts sodium carbonate in 40 per cent. of water, keeping up the boiling all the time.

(6) Add to silver chloride sodium hydrate in solution and grape sugar, and expose to sunlight in an open dish with occasional stirring. Reduce to dark-brown oxide of silver soluble in nitric acid.

* From the "Scientific American Cyclopedia of Recipes."

(7) Mix with five times its weight of sodium carbonate. Fill a Hessian crucible half full and sprinkle sodium chloride over the top. Heat slowly in anthracite fire. After half an hour increase the heat until the crucible is white hot. When complete fusion has taken place, allow to cool and break out the button of silver.

(8) Fuse with 2 parts carbonate sodium and potassium mixed.

(9) Add pure zinc and dilute sulphuric acid and let it stand two days. Wash silver off with water acidulated with sulphuric acid and remove all zinc; finally fuse to a button.

(10) Mix with one-half its weight sodium carbonate and one-quarter its weight of dry, clean, sand, and ignite.

Platinum Residues.—Platinum is now largely used in photography, in the different platinotype processes and in platinum toning, and is a sufficiently valuable metal to repay the worker to save what he can of it.

The following remarks concerning the recovery of platinum residues, are given in Lyonel Clark's book on platinum toning: "The old toning baths, and the washing water the prints are passed through after toning, are especially rich in the metal, and these liquids should be poured into any bottle, and an ounce or so of the ordinary ferrous oxalate developing solution added. The bottle should be stood aside, and the platinum will be found to be rapidly thrown down in the metallic state. The major portion of the liquid is decanted off, and the residue filtered and dried, and can be sent to the refiners at once, or it can be converted into platinum chloride for subsequent conversion into chloroplatinite of potassium. In case any iron should be present, it is best to treat the filtrate with a fairly strong solution of sulphuric acid; this will dissolve out any iron in the form of the sulphate without injuring the platinum; the residue should be washed and dried and dissolved in aqua regia (nitric acid one part, hydrochloric acid, four parts), with gentle warming. As little aqua regia as possible should be used, only just sufficient to dissolve the platinum, as it has subsequently all to be evaporated off. The dissolution of the platinum should be conducted out of doors, or in a well-ventilated room, as the nitrous oxide fumes given off are most unpleasant, and rapidly rust iron or steel objects. The residue left after evaporation is chloroplatinic acid, and can be weighed, and at once used for the production of the chloroplatinite of potassium.

Gold Residues.—To obtain the gold from old toning baths, add sulphate of iron either in crystals or in solution. This will precipitate the gold in a black powder, which is well washed and dried, and then dissolved in nitro-muriatic acid, when a solution of gold chloride will be the result. This can be evaporated to dryness, dissolved in distilled water, and again evaporated to remove all traces of acid. Another way is to reduce the black powder in a crucible, but an enormous heat is required.

RESIN PROCESS.—See **Cooper's Process.**

RESINS.—A widely-distributed class of vegetable substances frequently obtained by making incisions in the bark of trees.

Most of the resins are soluble in anhydrous alcohol, and many in ether, sulphide of carbon, and oils; soften or melt at a moderate heat, and at a higher temperature burn with a smoky luminous flame.

Many of the resins are employed in the manufacture of varnishes for photographic and other purposes.

RESORCIN (Formula $C_6 H_4 OH_2$). Occurs in prisms, soluble in water and alcohol, and having a bitter taste. It is employed as a developing agent, its action being similar to its isomerides quinol and catechol.

RESTORING DAGUERREOTYPES.—Old and faded Daguerreotypes can be restored by cleaning and immersing in a dilute solution of cyanide of potassium.

RESTORING NEGATIVES.—Negatives which have been intensified with mercury are very apt to fade and lose their brilliancy. This can be restored by soaking the negative in water for about five minutes, and then immersing in the following solution:

Schlippe's salt	10 grains.
Water	1 ounce.

until sufficient vigor has been restored.

RESTORING PRINTS.—Prints when kept some time previous to toning will often turn yellow or brown, and become completely discolored. This may, however, be restored by placing immediately before toning in a two per cent. solution of strong ammonia. After toning they are washed in a bath of similar strength, and, further, about one part of ammonia is added to the fixing solution. With this treatment the whites of the prints should be completely restored.

Finished prints which fade by the action of light or by other influences can never be satisfactorily restored.

RESTRAINER.—Any substance employed in order to lessen the energy of the reducing or developing action of the chemical solutions upon the exposed film. If a plate has been exposed and it is immersed in an ordinary developer the effect would be that the image would flash up rapidly, allowing the operator no control over its density, and when finished it would have a very unsatisfactory appearance, owing to the absence of detail in the high lights and other defects.

The simplest restrainer is water added to the developing solution which naturally weakens its action upon the film. Another method is to tan or harden the film, with tannin or chrome alum, for instance, causing the gelatine to be less permeable to the developer.

The soluble bromides and the citrates of potash soda and ammonia are all used as restraining or retarding agents The following formulæ for restrainers are from Wall's "Dictionary of Photography."

The restraining power of the bromides of ammonium, potassium and sodium bear the following proportions to each other :

Bromide of ammonium 98 parts are equal to 119 parts of potassium bromide and equal to 103 parts of sodium bromide. Ammonium bromide is consequently the strongest, and potassium bromide the weakest, while the sodium salt ranks between the two.

The citrates of potassium, sodium and ammonium, have apparently quite a different action, for while the bromides prevent to a certain extent the excessive deposit on the high-lights, and permit the detail to make its appearance, the citrates, on the other hand, appear to prevent the detail from making its appearance, and permit the density to be obtained.

To make these restrainers the bromides are simply dissolved in water as follows :

Ammonium bromide	98 grains.
Distilled water to make	980 minims.

of solution, each drachm of which will then contain six grains of bromide of ammonium.

Potassium bromide	119 grains.
Distilled water to make	980 minims.

of solution, each drachm of which will contain $7\frac{3}{7}$ grains of bromide of potassium, equal in restraining power to six grains of ammonium bromide.

Sodium bromide	103 grains.
Distilled water to make	980 minims.

of solution, each drachm of which will contain $6\frac{1}{3}$ grains of sodium bromide, equal in restrain ing power to six grains of ammonium bromide, or to $7\frac{3}{7}$ grains of potassium bromide.

POTASSIUM CITRATE RESTRAINER.

Citric acid	720 grains.
Potassium bicarbonate	944 grains.
Distilled water to make*	2½ ounces.

of solution.

AMMONIUM CITRATE RESTRAINER.

Citric acid	720 grains
Liq. ammonia .880	630 minims
Distilled water to make	2½ ounces

of solution.

SODIUM CITRATE RESTRAINER.

Citric acid	720 grains
Sodium bicarbonate†	884 grains
Distilled water to make	2½ ounces

of solution.

These solutions will keep for an indefinite period, and can be diluted by adding five parts of water. The advantage of these last three restrainers is that when a negative shows plenty of detail, but refuses to gain in density, the addition of a little of one of the dilute solutions may be made, and the plate left for hours, if necessary, till the required density is obtained, without the slightest sign of fog. ‡

In the collodion process, the action of the developer is usually restrained by the addition of some thickening substance, such as sugar, gelatine, etc. The collodial restrainer introduced by Carey Lea has found considerable favor among photographers.§ It is prepared by first soaking an ounce of French glue in one and a half ounces of water, to which one drachm of sulphuric acid has been added. When it has swollen up thoroughly, the water is boiled until the glue is dissolved. Another half an ounce of distilled water is then added, and the boiling continued a couple of hours. Eighty grains of granulated zinc are next added, and the boiling again continued for another hour and a half. The solution is then allowed to settle, and the clear fluid

* Or potassium carbonate 884 grains. † Or sodium carbonate (crystallized) 1,440 grains. ‡ E. J. Wall. § Capt. W. de W. Abney.

decanted off. To every three ounces of a fifteen grain solution of iron used in the developer one minim of this solution is added.

RETARDING AGENTS.—See **Restrainer.**

RETICULATION.—An effect sometimes observable on the collodion film when dry, and much resembling the pattern of crape. It is usually due to the solvents used in the manufacture of the collodion not having been sufficiently anhydrous, or it may be due to faulty pyroxyline.

RETOUCHING.—The art of retouching does not consist as is often supposed in making bad negatives into good, but in the perfection of good negatives. Under-exposed or over-exposed negatives will never give good results, however skilful the retoucher.

In landscape photography retouching should rarely be resorted to except in bringing up flat high lights, etc. Sometimes a negative can be improved considerably by coating the back with a matt varnish or pasting a piece of tissue paper to it and working lightly with a pencil or stump over the parts that are too transparent and by cutting out those parts that are too dense.

In portrait photography, however, retouching is almost an absolute necessity, as it is almost an impossibility to obtain truthful and satisfactory portraits by photographic means alone. We are well aware that one of the principal drawbacks in photography is its failure to represent colors in the same relative value as seen by the eye. In portrait photography, this defect is apparent to a considerable degree. For instance, fair complexioned sitters possessed of ruddy faces, come out dark, freckles appear as prominent black spots, pimples, blotches, wrinkles and facial lines often appear so exaggerated as to be positively objectionable, and alter the appearance of the sitter to a considerable extent.

The object of retouching is, briefly, to remove these effects by the judicious use of a sharply-pointed lead-pencil, without, however, destroying the likeness to the sitter, which many retouchers are apt to do.

For this purpose a retouching desk or easel is required, upon which the negative can rest firmly, and is lighted up with a reflector placed behind, so that the image can be properly seen by the worker.

The negative to be retouched is first varnished, and, when dry, the parts to be treated are dusted over with a little finely-powdered cuttle-fish. This is gently rubbed with the finger until the film has a rough appearance when viewed under a magnifying glass. Instead of this a retouching medium or matt varnish can be used.

The pencils used are usually very hard, Hardtmuth's or Faber's; HHH to HHHHHH are most suitable. The pencil should be sharpened into a long fine point, and then kept in order by occasionally rubbing on a piece of fine emery paper.

The transparent portions of the negative which give too dark a complexion on the positive can be filled up by careful stippling or interweaving pencil lines until they are brought into harmony with the surrounding parts. Pimples, freckles, blotches, etc., are thus removed, and the wrinkles and exaggerated lines softened down. This is what is termed smoothing the face.

FIG. 386. HARRY'S RETOUCHING MACHINE.

The next operation is the most important one, however, and calls for the skill and considerable artistic knowledge of the retoucher. It is termed "modelling the face," and consists in bringing the high lights, semi-tones and deep shadows into harmony with each other in accordance with the artistic laws governing light and shade.

Retouching machines have been constructed. They work by electricity. The pencil is given a peculiar movement which takes the place of the stippling. A machine of this kind is shown in Fig. 386.

The art of retouching is one that requires to be learned under the guide of a competent teacher. The principal thing is to know, on examining an untouched negative, what to do, and what not to do. Many make the great mistake of over-retouching, removing all individuality from the portrait.

Always make a print from the negative to act as a guide during retouching.

On the subject of retouching, H. P. Robinson says:*

"A very little unskilful retouching will remove the texture of the flesh and leave that of stone; will remove the expression of a living face, and leave that of a mask; whilst the same amount of retouching applied with knowledge and intelligence would have retained the texture of the flesh, removing only the temporary and accidental blemishes and the exaggerations of photography which interfered with truth and beauty; would have given fuller effect to a fine expres-

* "The studio, and what to do in it."

sion or subdued a suspicion of frowning or weariness by delicate touches applied in the right place. . . . . To know when to leave off should be the aim of the retoucher."

Chemical Retouching.—The principle of this method* consists in arresting the action of the developer on the parts of the negative which come up too rapidly. For this purpose, as soon as it is apparent that these portions are almost fully developed, the negative is removed from the developer, allowed to drain a moment, until there is no free liquid on its surface. Then all the portions where the detail is sufficient are painted by means of a camel-hair brush with a 5 per cent. solution of bromide of potassium. The gelatine absorbs this solution very rapidly, and the places may be gone over several times according as the detail is more or less out. The negative is then returned to the developer, and the development continued until the detail comes up in all portions of the negative. The development is nearly or quite arrested wherever the bromide was applied, and these portions do not gain in density. In the end a negative is obtained with detail throughout.

FIG. 387.—RETOUCHING GLASS.

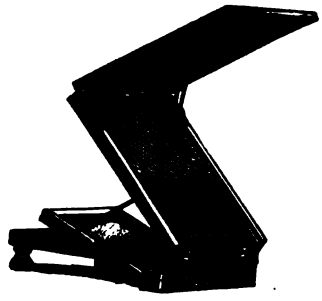


FIG. 388.—RETOUCHING DESK.

RETOUCHING DESK.—A desk or easel used in retouching the negative. There are many forms in the market. They all more or less consist of two frames and a lid, the bottom frame resting on the table holds a movable mirror, used to reflect the light to the underside of the negative ; to the front of this frame is hinged another frame, containing a piece of ground glass, on which the negative to be retouched rests, and which opens to an angle of about 30 to 45 deg. On the side farthest from the retoucher is hinged a light lid of wood, opening to nearly a right angle with the frame, on which the negative is retouched. This serves to shade the extraneous light from the eyes of the sitter, and can be supplemented with curtains on each side.

Instead of the mirror and ground glass, a sheet of white paper will often answer quite as well. A sheet of brown or black paper, with a small hole cut in it, can be placed over the negative to shut out all light except where the retoucher is working. This effectually prevents an excessive glare to the eyes, and gives greater brilliancy to that portion of the negative being worked on.

RETOUCHING GLASS or large magnifying glass, used when retouching, to better examine the negative.

RETOUCHING MEDIUM.—A kind of matt varnish rubbed or coated on the negative previous to retouching. It gives a biting surface for the pencil to work on. Two formulæ are—

No. 1.

Gum dammar	10 grains.
Canada balsam	5 grains.
Turpentine	1 ounce.

No. 2.

Shellac	75 grains.
Mastic	75 grains.
Sandarac	126 grains.
Ether	3 ounces.

Dissolved, and add

Benzole	4 drachms.

M. Piquepe's retouching medium is the following :

Dammar resin	240 grains.
Oil of turpentine	10 ounces.

REVERSAL OF THE IMAGE.—This is a term applied to the phenomenon resulting in a reversal of the image; those parts which should appear light becoming dark, and *vice versa*. Complete reversal of the image would result in a perfect positive instead of a negative.

If a photographic dry plate be exposed for a considerable length of time to the image, solarization takes place, resulting in a complete or partial reversal of the image. See **Solarization.** The addition of some of the thio-carbamides to the developer will result in a positive being obtained instead of a negative as usual.

* G. Mareschal, in *Photo Gazette*.

The author has obtained some fairly good positives by under-exposing the plate, and developing with the ferrous oxalate developer as far as possible. A small quantity of fixing solution (sodium hyposulphite) is then added to the developer, and the developed negative immersed in it. In a short time the reversal of the image will be complete, and a positive is obtained.

REVERSE ACTION OF LIGHT.—See **Solarization.**

REVERSED NEGATIVES.—Negatives with the image reversed in position as regards right and left. In photo-mechanical printing this is a necessity, otherwise the prints finally obtained would be incorrect, the right side being to the left, and *vice versa*. Reversed negatives can be made in several different ways. These can be divided into three different classes: First, reverse negatives obtained direct in the camera; second, negatives reversed by removing and reversing the films of the negative; third by reproduction from other negatives.

The simplest method under the first class is to photograph the image upon the plate reversed in the camera. To do this the back of the dry plate must be thoroughly clean, and also one should be selected having a perfect glass support, free from bubbles or other defects. The dry plate is then inserted in the dark slide, film side down, or the opposite to the usual way. A little care must be taken that the spring used for keeping the plate into position has no injurious effect upon the film. After focusing, the back or front of the camera is moved so that the distance between the lens and the screen is decreased exactly the thickness of the dry plate.

The next method of making reversed negatives direct in the camera is by means of a silvered reflector. Metal or glass silvered on the external surface should be used. The accompanying sketch, Fig. 389, will show how it is arranged: E is the camera, L the lens, A C B D is the section of a hood fitted round the lens and attached to the camera, A B is a mirror, as described, fitted at an angle of 45 deg. with the axis of the lens, and so arranged that the center of the mirror is its continuation, D is a small door which can be opened and shut at will. The camera is turned sideways towards the object, and a little consideration will serve to show that the image obtained on the focusing screen and upon the plate will be reversed.

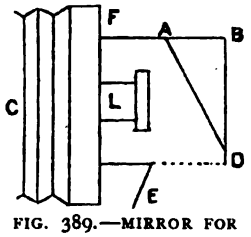


FIG. 389.—MIRROR FOR REVERSING.

In the third method of the first class a right-angle prism is used fitted on the lens. See Fig. 390.

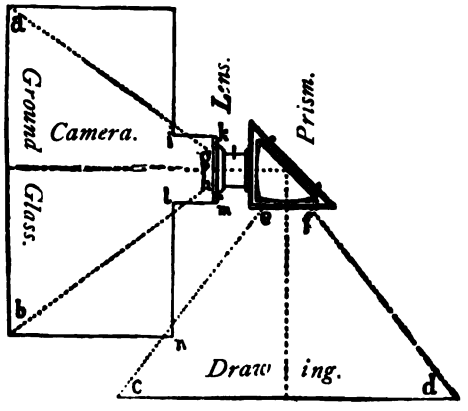


FIG. 390. PRISM ARRANGEMENT FOR REVERSING.

On reference to Fig. 390 the system will be seen at a glance. The prisms are made of one solid homogeneous mass of glass with silvered hypothenuse.

Of the second class, *i.e.*, negatives reversed by reversing the film, the most convenient method is the following: The negative is made in the ordinary way upon a gelatino-bromide plate. It is then washed and dried and coated with a solution of indiarubber dissolved in benzole, and when this coating is dry it is flowed over with transfer collodion, composed of—

Methylated spirit (.805)	2 ounces
Methylated ether (.730)	1 ounce
Pyroxyline	24 grains
Castor oil	24 minims

When this is dry the negative treated in this manner is immersed in—

Water	50 ounces
Hydrofluoric acid	½ ounce

The film should next be cut round the edges with a penknife and stripped away gently, and floated off into a bath of clean water to wash. A glass plate is then coated with a warm solution of gelatine (about five grains to the ounce), and the film floated on to it in the reverse position—that is to say, with the collodionized side downwards—with a soft squeegee it is pressed into contact with the glass, and then set aside to dry.

The best class of processes for producing reversed negatives is by reproduction. There are several methods. The powder process is very often employed; this will be found described under that heading. Bolas's method is as follows: A dry plate is soaked for five minutes in a four per cent. solution of potassium dichromate, rinsed once or twice with water, and then dipped into a bath of equal parts of methylated spirit and water, the superfluous mixture blotted off and dried. All these operations must be conducted in the dark-room. It is then exposed, under the negative to be reversed, to sunlight for three or four minutes, when a faint delicate image will

be seen impressed; it is then washed and developed with ferrous oxalate or alkaline pyro, and fixed and washed as usual. The result is a reversed negative image.

Now that sensitive bromide negative films are made so perfect, there is no doubt that they will be largely used in obtaining negatives required to be reversed, as they can be printed from either side with the same effect.

REVERSING BACK.—A very useful arrangement in many modern cameras. It is well known that the different sizes of photographic pictures are always longer one way than another. In landscape Photography one is often confronted with the difficulty of deciding whether the picture would have the best appearance vertical or horizontal. In the case of photographing high buildings, too, it is often difficult to tell whether they would be all included on a horizontally-arranged plate. In the common forms of camera, without the reversing back, it is necessary to unscrew the camera from the baseboard or tripod, alter its position from horizontal to vertical, or *vice-versa*, and re-adjust. This operation naturally involves considerable time and trouble. With the reversing back, however, the camera is made square instead of oblong, and that portion of the back which holds the focusing screen, and the grooves in which the dark slide fits, is so constructed as to be readily detached. It can then be turned round from one position to the other, and sprung into place in the space of a few seconds only. Although with this arrangement the camera is somewhat bulkier and slightly heavier, yet these drawbacks are fully balanced by the additional convenience it affords. See also **Revolving Back.**

REVOLVER CAMERA.—A small instantaneous camera made in the form of a revolver.

REVOLVING BACK.—A method of reversing the back by revolving it. See Fig. 391 and **Reversing Back.**

REVOLVING BACKGROUND.—A circular graduated disc revolving on a pivot attached to a stand. It is used in portrait photography, placed behind the sitter, and revolved until the correct light and shade effect is obtained.

RISING AND MOVING FRONT.—A movement now arranged in nearly every camera. It consists in constructing that portion of the front of the camera to which the lens is attached in such a manner that it can be raised, lowered, or moved to either side, and by means of clamp screws adjusted in any position. This movement is especially useful in making pictures of architectural subjects; by shifting the position of the lens a picture is often obtained difficult or undesirable to get in any other way.

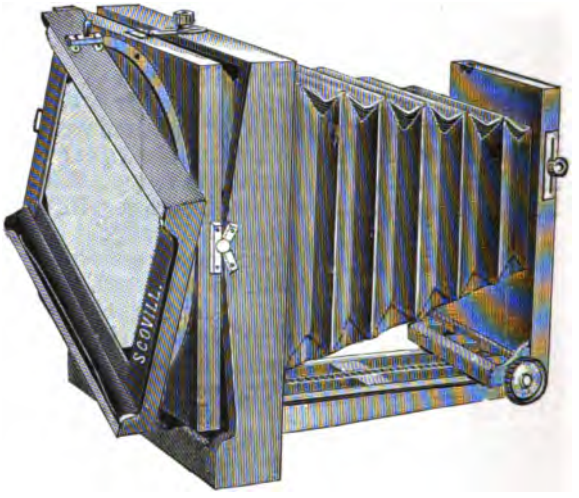


FIG. 391.

RIVE PAPER.—A very fine class of paper manufactured at Rive-de-Gier, or simply Rive, a town of France in the department of the Loire. It is of a very fine and even texture, and is largely used for photographic purposes.

ROCKER.—An arrangement for keeping the dish rocked during the progress of development.

ROLLER SLIDE.—See **Roll Holder.**

ROLLER SQUEEGEE.—A wooden revolving roller attached to a handle and coated with indiarubber. It is used for mounting prints, or for squeegeeing gelatine prints upon glass. For the latter purpose, however, the straight edge squeegee is preferable. They are also made with two rollers. See **Squeegee.**

ROLL HOLDER OR ROLLER SLIDE.—An arrangement for holding a continuous band of paper or other flexible substance, coated with a sensitive emulsion, in the camera during exposure. The first roller slide was introduced by Mr. A. Melhuish, about the year 1861, and was used for making paper negatives.

In the usual roller slide the film is unwound from one spool in equal lengths corresponding to the size of the plate for which the holder is designed, and after it has received the exposure it is again wound on to another roller termed the clamping reel. In this manner a large number of exposures can be made upon a long band of paper or film, and this is then cut up, and each picture developed.

It is exceedingly compact and very light. When a perfect flexible film has been discovered, the advantage over glass plates will be incalculable.

The best form of roller slide is that known as the Eastman-Walker roll-holder. It is constructed in three parts, a body consisting of four side, together with the top and bottom. These latter are held to the body and together by two simple springs which pass down the ends, and by a mere pressure of the finger the roll-holder can be taken apart instantly, and its contents got at in all directions. Inside the body are fitted four rollers, two being small and permanent, and merely form runners for the film to pass over in its passage between the spool-holders. The other two are large rollers, fitted to attachments screwed into the sides of the frame. They are easily removable, and one fits on to an attachment provided with a brake, which serves as an automatic tension, keeping the film stretched flat and smooth, and prevents it being too freely unwound. There is also an audible and visible indicator, enabling the operator to be perfectly assured, both by sight and sound, that each exposure has been correctly wound off, and a new length placed in position ready for the next exposure. The film is also marked with an automatic perforator, so that no error can be made in cutting up the paper previous to development.

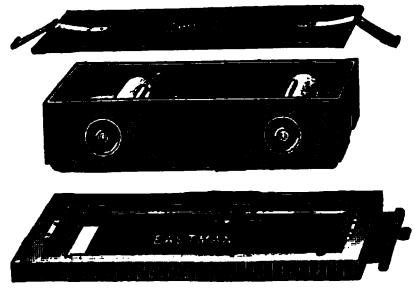


FIG. 392.

This roll-holder, although occupying the space of three double dark slides, contains sufficient material to make 50 or more exposures.

It can be easily adjusted to any ordinary camera, care being taken that the position of the film coincides with the plane of the focusing screen.

ROLLING PRESS.—A contrivance for flattening and giving a finishing surface to photographic prints, either mounted or unmounted. They are made either with two polished steel rollers, between which the print passes, or with a roller and a polished steel plate. The steel plate upon which the cards are laid is often so arranged that it can, if necessary, be heated with a gas or spirit lamp. By this means the cards are given a uniform and highly finished surface, similar to that obtained by burnishing. The pressure of the roller upon the steel plate should be perfectly even and under the control of the operator.

ROSE TAP.—A tap fitted with a rose similar to that used for ordinary garden watering-cans. The water comes out as a fine spray from the number of holes contained in the rose. It is very useful for washing negatives and prints, as the water running direct from the tap as a heavy stream will often destroy the gelatine film or the prints.

ROSIN.—See **Resins.**

ROTTEN STONE.—A mineral found in Derbyshire. It is reduced to a fine powder, and used for polishing metals, Daguerreotype plates, etc. For the latter purpose it should be sifted through fine muslin.

ROUGE.—Red oxide of iron. It is used for polishing metal, glass, etc. Daguerreotype plates should not be polished with it, however, as the iron clings to the silver and injures the tone of the picture.

R. R. LENS.—An abbreviated term for a rapid rectilinear lens.

RUBBER FINGER STALLS.—Finger stalls made of indiarubber are very useful when working with poisonous chemicals.

RUBBER STAMP.—Rubber stamps are now too well known to need any description. They can be made very useful to the photographer for numbering, naming, and marking negatives. For this purpose the movable reversed type should be used. A non-actinic ink is also necessary, and the name stamped backwards upon the film. If reversed type is unobtainable, the transfer aniline ink used in the gelatine copying apparatus should be used. The name, etc., is then printed on to a piece of paper, and when dry this can be transferred to the negative while the latter is still moist.

RUBY GLASS.—Ruby glass is usually obtained by the addition of sub-oxide of copper and a litle gold. It is used in photography as a non-actinic medium.

RUBY LIGHT.—See **Non-actinic Media.**

RUBY VARNISH.—See **Varnish.**

RUST SPOTS.—Rust spots sometimes make their appearance upon lenses, and may be removed by placing the spots in contact with chlorhydric acid diluted with a little water.

SAFE EDGE.—In carbon printing a thin strip of black or non-actinic paper pasted round the negative on the *glass* side is termed a safe edge. If the negative be masked on the negative side so as to print white, and should there be a heavy shadow in the picture coming against this portion, it is very likely to wash up in developing. The safe edge, however, prevents this.

SAL AMMONIAC.—See **Ammonium Chloride.**

SALICYLIC ACID (Formula, $C_7H_6O_3$; synonyms, *spinoylic acid, orthohydroxy-benzoic acid*). —A dibasic acid found in the flowers of the *spiræa ulmaria*, or obtained by heating sodium phenol to 180 deg. in a stream of carbon anhydride. It has a sweetish-sour taste, is slightly soluble in cold, more so in boiling water, and very soluble in alcohol and ether. It is principally used as an antiseptic and antiputrefactive agent.

SALT, COMMON.—See **Sodium Chloride.**

SALTED PAPER.—Paper prepared with a chloride. On sensitizing on a nitrate of silver bath, sensitive silver chloride is formed. Albumenized paper containing a chloride is sometimes termed salted paper, but the term is more generally applied to paper prepared for matt surface or plain paper prints.

SALTPETRE.—See **Potassium Nitrate.**

SALTS.—When an anhydride and a base are brought together they usually combine to form a salt, the distinctive properties of both being lost in the resulting compound.

All salts may be made to form an acid or a base, but they are not all neutral to test paper —for instance, carbonic acid is so weak an acid that it has not sufficient power to neutralize the alkalinity of the soda when it combines with it to form sodium carbonate, this being nevertheless a salt, however, as it has its acid and its base.

SALTS, HALOID.—Chlorine, bromine, iodine and fluorine are four elements which compose a natural group, the members of which are connected by the similarity of their chemical properties far more closely than those of any other group of elements.* They are usually termed the halogens, from their tendency to produce salts resembling sea-salt in their composition, such salts being called haloid salts.

SALTS OF TARTAR.—See **Potassium Carbonate.**

SANDARAC (Synonym, *gum sandarach* or *sandarac*).—A gum exuding from the *Callitris quadrivalvis*, one of the *cupresseæ* growing in Barbary, where it is called the Arar tree. Sandarac usually occurs in small whitish-yellow drops. It is a brittle, inflammable, resinous substance, with an acrid aromatic taste. Soluble in ether, alcohol, and benzol. It is used in making varnishes. About five per cent. is usually added to give more evenness to the film. If large quantities be used the varnish will be too soft.

SATIN, PRINTING ON —Prints may be made upon satin by treating with silver chloride in the same manner as with silk (see **Silk, Printing on**). Images may also be made upon satin stuffs by the diazotype or primuline process. See **Primuline Process.**

SATURATED SOLUTION.—When a solid is dissolved in a liquid, the first portions added may disappear quickly enough, but as more is added solution proceeds more and more slowly, until it ceases altogether, and any more of the substance added will sink to the bottom and remain there. The solution is then said to be *saturated*. See **Solution.**

SAXE PAPER.—A fine even textured paper, manufactured at Saxe, in Germany, and much used for photographic purposes.

SCARF CAMERA.—A small toy instantaneous camera hidden behind a scarf, the lens protruding through the latter, and made to represent a scarf pin.

SCENIC BACKGROUND.—See **Background.**

SCHLIPPE'S SALT (Sodium sulphantimoniate; formula, $Na_3Sb\ S_{49}H_2O$).—Obtained in fine transparent tetrahedral and very deliquescent crystals by dissolving sulphide of antimony in sodium hydrate and adding sulphur. Freely soluble in water. It is sometimes employed for the intensification of collodion negatives.

SCIAGRAPHY.—The act or art of correctly delineating shadows in drawing; the art of sketching or reproducing objects with correct shading.

SCRATCHES.—To prevent the negative from being scratched it is coated over with a protective varnish, which will preserve it to some extent. Accidents will often happen, however, and

* Bloxham's "Chemistry."

the films get scratched. They can sometimes be retouched with suitable color, or can be filled up with black or non-actinic color, so as to print as a white line in the positive picture, which can be better worked out with suitable color. If the glass side of the negative has large scratches on it they will usually show in the print. There are two ways of overcoming this difficulty. First, by moving the frame round during the printing operation, and second by cleaning the scratches and filling them up with Canada Balsam, slightly thinned with benzol, no traces will be discernable on the print, as that substance possesses nearly the same index of refraction as the glass.

SCREEN, FOCUSING—See **Focusing Screen.**

SEALING WAX.—The term wax applied to this article is a misnomer, no wax being used, but resin, which is essentially different in its properties. The best kind is made with shellac, the inferior sorts of common resin. The best red sealing wax is made by melting 4lbs. of light colored or bleached shellac with 1lb. of Venice turpentine and 3lbs. of Chinese vermilion. Golden sealing wax is made by using powered yellow mica or cat gold, instead of vermilion. Ivory black is used for black wax. An inferior kind may be made by substituting common resin for the lac, red lead for the vermilion, and common turpentine for that of Venice. A common black wax for bottles can be made with 6lbs. of black resin, ½lb. beeswax, and 5½lbs. lampblack.

SEED LAC.—When the lac is broken from the twigs and washed in water it breaks into small particles called *seed lac.* It is used in the manufacture of varnishes, and is more soluble in alcohol than shellac.

SEL D'OR.—See **Gold Hyposulphite.**

SELF-TONING PAPER.—A paper prepared principally for the use of amateurs and tourists. It requires no special treatment to get an agreeable tone. The paper, after printing, is merely washed and fixed, when it takes a brown color instead of the dirty yellow obtained with ordinary paper thus treated. Only a brown tone, however, can be obtained. After fixing and washing the prints are laid between sheets of blotting paper, and afterwards dried under a hot iron. The hotter the latter the greater the brilliancy of the prints, although scorching must be avoided. A new self-toning paper has recently been placed upon the market, by means of which very good black tones can be obtained. The preparation is a trade secret.

SEMI-OPAQUE.—Half opaque and half transparent.

SEMI-TONES.—Half-tones.

SEMI-TRANSPARENT.—Half or imperfectly transparent.

SENSITIZE.—To render sensitive or capable of being readily affected by the action of light.

SENSITIZED PAPER.—This term properly includes any kind of prepared paper sensitive to light, the action being either visible or latent and made visible by development. It is more generally applied, however, to albumenized or plain paper treated with a chloride and afterwards floated on nitrate of silver. See **Sensitizing.**

Sensitized paper unless specially prepared will not keep for any length of time. That sold commercially is all prepared with acids as preservatives. The addition of 10 drops of perchloric acid to every ounce of the sensitizing solution is often recommended.

Ashman's method is as follows. The paper, when surface dry, is floated on one of the following solutions properly made up and filtered :—

No. 1.

Picked white gum arabic	½ oz.
Rochelle salts	1½ "
Distilled water	20 "

No. 2.

Picked white gum arabic	½ oz.
Tartaric acid	1½ "
Distilled water	20 "

After the paper is dry it should be stored away in sheets of sodaic blotting paper (*q.v.*) No. 1 will preserve it for about a fortnight and No. 2 for several months.

SENSITIZER.—Any substance added or applied to a photographic material to increase or alter its sensitiveness to light.

SENSITIZING.—The operation of causing the albumenized paper to become sensitive to light. This is done by floating the surface of the paper already prepared with albumen containing a chloride upon a solution of silver nitrate. (See **Silver Bath.**) The albumen soaks up a portion of the silver solution, which combines with the chloride and albumen to form silver

chloride and silver albuminate, these compounds, being sensitive to light, darkening rapidly by its action.

The operation of sensitizing must be performed either by gas-light or during the day in a room lighted with windows covered with yellow paper or fabric. The room should be kept scrupulously clean and free from dust, and be fitted up with a convenient arrangement for hanging the paper lines; or string stretched across the room with American clips strung along them will be found very convenient. The dish containing the sensitizing solution should be conveniently larger than the sheets of paper to be sensitized. It should be placed on the table as near to the window as possible to get plenty of light to work with. Over the bath should be fitted a few American clips to hold the paper by one corner, and at such a height from the bath that the bottom corner of the sheet is nearly touching the liquid in the bath; this prevents splashing in drawing, and also the formation of air-bubbles.

The bath is placed lengthways before the operator, and the silver solution poured in. With a thin strip of blotting paper the surface of the liquid is skimmed, removing any scum or air-bubbles.

The paper to be sensitized should neither be too hard and dry, nor too moist. In very hot and dry weather it is advisable to place the sheets in a cool damp cellar for some little time before floating.

The paper has now to be floated, prepared side downwards, upon the silver solution. This is done by first turning up a small portion of each corner of the sheet for convenience in examining and lifting it from the bath. Two diagonally opposite corners are now held with the thumb and first finger of each hand, and the sheet curved slightly inward. That part of the sheet nearest the left hand is lowered gently on to the center of the solution, and the sheet slowly drawn on to the solution, steadily lowering the right hand, until the whole sheet is floating in contact with the solution, with the exception of the four upturned corners.

If this method be followed no air-bells will form between the paper and the solution. After a little time the corners are gently raised and lowered again one at a time to enable the operator to examine the progress of the sensitizing operation. Any air bubbles visible should be removed before again lowering the corner on to the solution. If any of the solution should by accident get on to the back of the paper it should be blotted up at once with a piece of blotting paper. It often happens that the paper after floating will curl up, the corners and sides leaving the solution. The cause of this is that the paper is too dry; by breathing hard on to it the paper can be made to resume its position on the solution.

With regard to the correct time the paper should be allowed to remain upon this solution, this depends both upon the strength of the bath and the temperature of the solution and of the atmosphere. Further, different brands of paper often require different lengths of time for sensitizing, and it is also influenced by the character of the negative and the effect to be produced in the resulting print. Many operators sensitize their paper of different degrees of strength for the various negatives from which they have to print; for instance, for weak negatives, a paper sensitized strongly. The usual time, however, may be said to vary from 40 to 70 seconds in the summer, and from 60 to 100 seconds in the winter.

The correct time for sensitizing, as has already been stated, is dependent upon so many considerations that some amount of thought and experience is required by the operator to get the best class of results.

After the sheet has been allowed to remain for the required time upon the solution, it is slowly raised by two corners and drawn slowly over the edge of the dish, or preferably over a glass rod attached to one side of the dish. In this manner the superfluous solution is removed from the surface of the paper. Some operators prefer to do this by laying a sheet on a piece of bibulous paper, but unless this be perfectly pure and free from antichlor, the method is rather risky.

The sheet is next fixed at one corner to a clip, and at the opposite or lowest corner a piece of white blotting paper is affixed to absorb the moisture.

The drying of the paper is an important point. It should not be done spontaneously, as the silver solution will then sink into the paper, and the brilliancy of the prints is lost.

The sheet is first allowed to drain and become partially dry, and then finished thoroughly by heat in a drying cupboard fitted with a row of gas jets or a stove. In this the top of the sheet is attached to two clips. If it be found that the paper curls up in drying, pieces of wood the same length as the paper with a clip at each end are fixed to the lower edge of the paper to keep it straight.

The heat for drying should be diffused and sufficient to quickly dry the sensitized paper.

The following are the failures likely to be met with in sensitizing albumen paper, and the causes.

The paper repels the silver solution. It is too dry.

White spots are produced if bubbles of air are allowed to remain beneath the paper when floating. The corners should be lifted up as soon as paper has settled down and the air-bells removed.

Small drops of the silver solution termed "tear drops" adhere to the sheet when hung up to dry. They should be blotted off immediately, and are caused by the paper being too dry.

The paper discolors quickly if over-sensitized.

A dull and sunken-in appearance of the image may also be caused by over-sensitizing.

Bronzing of the dark shadows is also sometimes the result of over-sensitizing.

Poor, weak prints are usually produced by too short sensitizing. Greasiness of the paper is also produced either by insufficient sensitizing or by the solution being very cold. Unpleasant foxy-reddish tones of the prints are often caused by too short floating on the sensitizing bath.

The curling of the paper on the solution is caused by the paper being either too dry or the albumen film being too tough. Breath on the back of the paper until it lies down flat again.

Stains are sure to appear if the sheet is allowed to come in contact with any unclean substance.

Dark stains on the back are produced by the silver solution running over the back.

Small dark spots or specks are caused by small metallic pieces of dust imbedded in the paper. They can sometimes be removed with the sharp point of a knife.

Inequality in the prints is due to uneven sensitizing.

SENSITIZING BATH.—See **Silver Bath**.

SENSITOMETER.—An instrument for comparing the sensibility of various photographic sensitive surfaces. There are various forms, which are, however, all more or less imperfect. The reason of this is that a standard light is required, perfectly uniform, and reproducible at any desired place or time. A light of this description has never yet been found, nor has any means yet been devised of calculating the difference between an accepted standard and an actual light made as near to it as possible.

Warnerke's Sensitometer is the one generally employed in testing various photographic sensitive surfaces. It consists of a transparent scale of figures made by the Woodbury process, the transparency of the scale decreasing by regular degrees from 1 to 24. Under this scale the plate to be tested is exposed for a given length of time. Warnerke employs what he terms a normal light, that is, a glass pane coated with a phosphorescent paint. Before this, two-and-a-half centimeters of magnesium wire are burned, then the whole is left undisturbed a minute, when it is placed upon the scale under which the dry plate lies. This light is considered as always uniform, but this is not so, however, as the temperature has a very marked effect upon the luminosity of the phosphorescent paint, the mere warmth of the hand increasing it. Further, this instrument possesses the drawback of being unable to register small differences.

Taylor's Sensitometer.—In this a more perfect method of graduating the light that reaches different parts of the plate from a uniform source is employed by means of a series of varying areas of a uniformly illuminated surface. The apparatus first employed by Arthur Taylor, in 1869, consists of a box containing a series of short wide tubes, each of which was open below to the sensitive surface, and closed at the upper end with a diaphragm perforated with a certain number of exactly uniform holes. The intensity of the light acting upon the sensitive surface at the bottom of any tube is proportional to the number of holes in the cover at the upper end of the tube.

Vogel's Sensitometer is an improvement upon the previous one. The scale is formed by a metal plate with holes. This plate covers a wooden block in which twenty-four cylindrical cells are drilled. Above the first cell one hole is made, above the second two, above the third three, and so on. Under these cells, the plate to be tested is exposed in a dark-slide-like contrivance, and it is obvious that the relative clearness under the different cells must be in exact proportion to the number of apertures made above the respective cells. When, therefore, two plates are exposed equally long under this instrument before an object uniformly illuminated and then developed, it may be that one plate will show the effect of light up to cell number two (with two holes), and the other up to cell number four (with four holes). With half the strength of the light the same result was obtained with the first plate as with the whole strength in the second plate, and the first plate is therefore shown to be twice as sensitive as the second.

Mucklow and Spurge's Sensitometer.—This is also similar to Taylor's, except that the diaphragms have one opening each, the openings being made of the required sizes. It is obvious that when a developable film is being tested the light must be graduated, because a uniform effect cannot be secured (the time then being in inverse ratio to the sensitiveness), as the result is not apparent until development.

SENSITIVE.—Capable of undergoing change by exposure to light.

SENSITIVENESS.—The sensitiveness of photographic substances, films, plates, paper, etc., is determined by the amount of time required for a given quantity of light to impress itself upon them either visibly or rendered visible by after development. The sensitiveness of dry plates is usually calculated by means of Warnerke's sensitometer. This method is, however, far from being perfect, and although plates are often sold with the sensitometer number marked upon

the box containing them, yet this cannot be taken as a sure guide to their rapidity of action, and the numbers are often more misleading than otherwise.

The sensitiveness of dry plates can be considerably increased by immersing them for from three to five minutes in a solution of 100 parts of alcohol ·805, one to two parts of a 1 in 15 solution of nitrate of silver, and ten parts of ammonia. They are then dried and used immediately.

SEPIATYPE.—A platinotype process introduced by Willis, giving sepia tones. See **Platinotype.**

SESQUICARBONATE OF SODA.—See **Soda Bicarbonate.**

SESQUIOXALATE OF IRON.—See **Ferric Oxalate.**

SESQUISULPHATE OF IRON.—See **Ferric Sulphate.**

SHAPES, CUTTING.—See **Cutting Moulds.**

SHEATH.—An arrangement for holding the dry plates in magazine cameras so that they are protected from the light and can be conveniently changed at will. They are usually made of darkened metal.

After a time sheaths will wear bright, and often in this state produce fog by reflecting light on to the plate. A little black varnish thinned with turpentine should be brushed over them. They are also very liable to rust. To prevent this rub them over with a little vaseline, applied with a rag. This has also the effect of making them work more smoothly when changing.

SHELLAC (Synonym, *gum lac*, *button lac*, *seedlac*).—A reddish-brown, fusible, brittle and inflammable substance occurring in thin sheets. Bleached lac occurs in white opaque brittle masses. These should not have a shiny appearance on the exterior, as this denotes that a change has taken place, and the substance will be found more or less insoluble.

Lacs are all soluble in alcohol, and in water containing borax, sodium carbonate, caustic soda, or ammonia. They are principally used in the manufacture of varnish. A shellac solution is not suitable for a varnish without the addition of sandarac or other suitable substance to give it the required elasticity.

If ammonia be mixed with an alcoholic solution of shellac the latter may be mixed with all proportions of water.

SHELLAC MOUNTANT.—Made by dissolving one ounce of shellac in four ounces of methylated spirits, and allowing to stand for some time, when the solution will be ready for use. Another method is to dissolve the shellac in a hot solution of borax and water, but the borax is liable to spot the prints.

SHUTTER.—For ordinary photographic work the lens is fitted with a cap which covers its front, and which is removed when making the exposure. For many classes of work, however, a shutter is necessary; for although it is possible to make a very rapid exposure by removing and replacing the cap as quickly as possible, yet it will be understood that exposures of 100th of a second cannot be possibly done in this manner. The shutter is, therefore, a mechanical arrangement to effect this, and a very great variety have been constructed. They may be divided into the following classes:

1. (*a*) The simple flap shutter. (*b*) The double flap. (*c*) The flap and drop.
2. The simple drop shutter.
3. The "go and return."
4. The roller blind shutter.
5. The diaphragmatic.

With regard to the first-class it may be stated that they are of little service for very rapid exposures, and that they give a longer exposure to the foreground than to the sky—an arrangement of great service at times when the contrast is very great, as it often is.

The simple drop shutter, when properly constructed, is capable of giving very rapid exposures, and is for this reason very often employed. It is usually a plate of wood, metal, or ebonite, which falls by gravitation in front of the lens. The center of the falling piece has an aperture of a certain length (see fig. 394) usually two or three times the diameter of the lens. Its rapidity can, of course, be increased by means of an elastic band or spring.

Of the "go and return" class there are two well-known forms, one of which works in the diaphragm slot and the other in front of the lens.

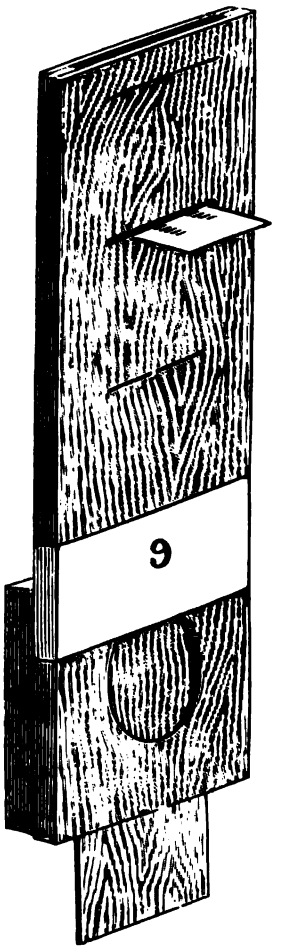


FIG. 393.—DROP SHUTTER.

These are more useful for prolonged exposures, but many, however, have a tendency to shake the camera when pushed to the utmost by the spring just at the critical moment when the lens is fully opened. The consequence is, of course, a blurred image.

The roller blind class includes several well-known and tried shutters. They are perfectly free from vibration. Many of them can be used both as time and instantaneous shutters.

The diaphragmatic class includes all shutters working between the lens combinations. One of the advantages is that the position of this shutter enables smaller moving parts to be used.

Shutters are usually set in motion by releasing a catch with the finger, setting the spring or weight into action. A better system, however, is that known as the pneumatic release. It consist of an indiarubber tube attached to a piston, and having at the other end a hollow indiarubber ball. By pressing the ball air is forced through the tube, causing the piston rod to release the shutter. By this means shaking camera is entirely avoided ; the exposure can be made at any distance without exciting attention, and if the tube be long enough it is possible to photograph oneself, or be included in a group of one's own taking. The requirements of a shutter are thus summed up by Chapman Jones: " A shutter should be small, that it may not catch the wind, light, that it may not strain the lens mount or camera front ; simple that it may be easily repaired by the user, quickly fixed to or removed from the lens, and need no change whatever in either the camera or lens."

In order that the shutter may be used intelligently, it is necessary that the lengths of exposure given by it should be accurately measured. This is usually done by photographing a body, falling at a known rate, and measuring the length of the impression. A simple plan is to have a large black circular disc, having towards its edge a white clearly-defined spot. This disc is revolved at a given speed--say, one second per each revolution. An exposure is made with the shutter, and on development the length of the image is calculated—if it has moved, say ten degrees of the circle, the exposure given by the shutter was the $\frac{1}{36}$ of a second. It is important that the image of the moving object be as near to the center of the plate as convenient, as the edges usually get less exposure.

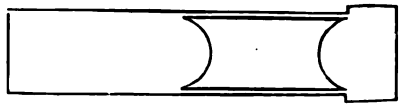


FIG. 394.—APERTURE OF DROP SHUTTER

M. T. D. Tissandier has devised a simple apparatus which is still more effective. This apparatus consists of a rotating disc of some white substance having its face smoked to blacken it, and a spring attached to the disc, the end of which is a fine needle having a slight pressure upon the disc sufficient to remove the black coating The spring is put in motion by the leves at the bottom shown in Fig. 395. To measure a shutter the instrument is set up facing the camera in a strong light—sunlight if possible— the lever is worked and the spring commences

FIG. 395.

FIG. 396.

FIG. 397.

to vibrate. The disc is then set in motion and the result of a short exposure is shown in Fig. 396, the needle attached to the spring making the curves as shown. If the speed of vibration of the spring and the rotation the disc be known it is easy to calculate the speed of the shutter by the length of the sinuous lines which were photographed on the plate. If, however, the time of exposure be greater than that required for the disc to make one revolution, it is not a difficult matter to so modify the instrument that it will record the exposure in the form of a spiral as shown in Fig. 397.

Another apparatus has been devised for this purpose by Addenbrooke. A sensitive plate is caused to revolve at a given speed behind a small opening made in an opaque screen, in front of which magnesium ribbon is burnt. The shutter is fixed between the light and the aperture of the screen. The proportion that the curved line of the developed image bears to the whole circle is the proportion that exists between the time of one revolution of the plate and the expo-

sure given by the shutter. For example, if the plate makes one revolution per second, and a tenth part of a circle is produced on development, it is apparent that the duration of time the light was admitted was the one-tenth of a second.

In photographing moving objects it is useful to know the maximum amount of exposure

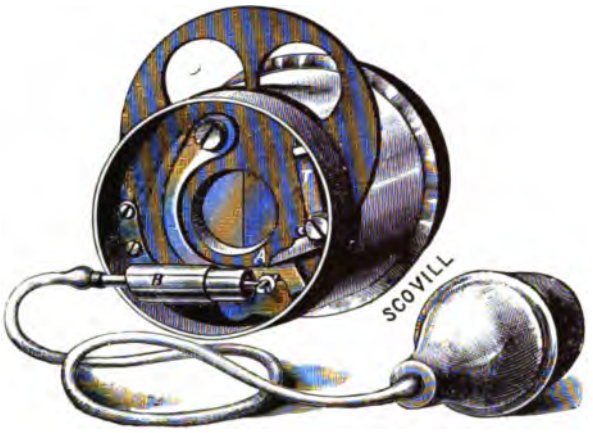


FIG. 398.

FIG. 399.—DROP SHUTTER.

FIG. 400.—DROP SHUTTER.

FIG. 401.—DROP SHUTTER.

that can be given at different distances. The following calculations of W. Groves* will enable one to do this satisfactorily:—

Let x = distance of image from lens (*i.e.*, focal length) in feet;
y = " object " in feet;
d = amount of movement of object permissible in feet;
v = velocity of object transversely to axis of lens in feet.

Assuming that the amount of movement of the image on the plate permissible is $\frac{1}{100}$ inch, that is, $\frac{1}{1200}$ foot, we have

$$\frac{d}{\frac{1}{1200}} = \frac{y}{x} \qquad \therefore d = \frac{y}{1200\,x}$$

Now, $\frac{v}{d}$ = the number of times the object traverses the permissible distance in each second;

∴ Time lens may be uncovered (speed of shutter) =

$$\frac{1}{\frac{v}{d}} \text{ sec.} = \frac{d}{v} \text{ sec.} = \frac{y}{1200.xv} \text{ secs}$$

Examples;—
If $x = 8''$ ($\frac{2}{3}$ foot), and $y = 10$ feet, and $v = 4\frac{1}{2}$ feet per sec., then

$$\text{Speed of shutter} = \frac{10}{1200 + \frac{2}{3} + \frac{9}{2}} = \frac{1}{360} \text{ secs.}$$

$$\text{If } y = 20 \text{ feet speed} = \frac{2}{360} = \frac{1}{180} \text{ sec.}$$

$$\text{If } y = 30 \text{ feet " } = \frac{3}{560} = \frac{1}{120} \text{ sec.}$$

With many shutters very little effect is produced on the plate during the periods near opening and closing, and it is probable that the minimum time of exposure in such cases might be one-fourth or one-third more than the above without visible blurring.

Captain W. de W. Abney explained before the Camera Club, of London, a short time ago, his method of measuring the speed of photographic camera shutters, which has special advantages as regards accuracy and facility of record, brought about in a somewhat novel manner. In a report of his lecture, which we extract from the London *Amateur Photographer*,† are several interesting facts. The lecturer pointed out that it was quite as important to know whether we were giving an exposure of, say, $\frac{1}{10}$ or $\frac{1}{60}$ of a second as one of 5 or 15 seconds. The apparatus enables us not only to measure the time of exposure, but also causes any kind of shutter to draw its own diagram, and from this diagram several things are made known, *e. g.*, how long it took to

* "British Journal of Photography," 1891, p. 45.
† We are indebted to the *Scientific American* for the loan of the cuts illustrating this article.

open, and to close, and how long the working aperture of the lens was fully open, etc.—three points of very great practical importance. The apparatus employed is somewhat as follows:

A source of light; in this case the electric arc, but magnesium can be used; the essentials being a steady and strong actinic light.

A supplementary positive lens. This is so placed that it throws an image of the carbon points upon the lens in the front of the camera.

The electric arc lamp will be noticed at the right hand of the end of the engraving, which projects a beam of light upon the condensing lens supported on a stand, and this in turn concentrates the beam upon the shutter to be tested, which is held in an upright stand next to its left. The actuating bulb of the shutter will be seen upon the table. Different makes of shutters can be held by this stand. The stand next on the left supports a spectroscope tube without any lens, having the slit two inches long by $\frac{1}{10}$ of an inch wide, in a horizontal position. A cardboard with

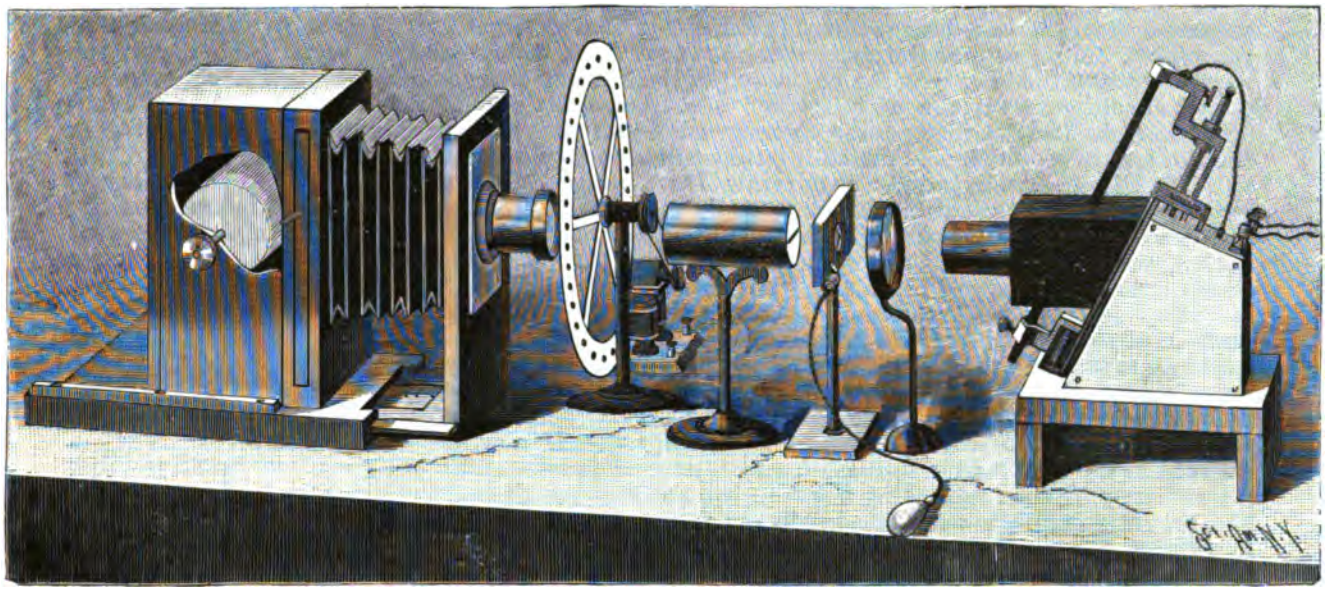


FIG. 402.—APPARATUS FOR MEASURING THE SPEED OF SHUTTERS.

a slit cut in it, inserted in the tube, answers as well as the regular slit. The condensing lens is adjusted with reference to the light so as to fully cover the whole of the horizontal slit. The motion of the shutter is in the direction of the length of the slit in the card.

At the left of the spectroscope stand is a rotating circular cardboard disk divided into six sector openings divided only by a narrow radial bar. The apparatus reminds one of a wheel with only six spokes. Along the rim are punched out a series of small holes, equidistant. Six of these holes correspond to each sector opening, so that there are thirty-six holes in all. The apparatus is made to revolve (about its center) in a vertical plane just in front of the lens of the camera, and as each spoke of the wheel passes in front of the lens, and is parallel to the slit in the tube, it intercepts the light. The wheel is made to revolve at a uniform speed by a small electro-motor which will be seen to the left of it. It is important to know the wheel's rate of revolution. This may be done in two ways. First, by blowing air through a small tube perpendicular to the plane of the sector and just opposite the row of the thirty-six holes, it becomes (effectively) a siren. The pitch of the note gives the number of air puffs passing through the holes, and so the rate of revolution is known. For example, suppose the air puffs gave a note agreeing with a tuning-fork which was known to vibrate 720 per second, we should know that 720 air puffs had passed through the tube and holes opposite in a second. Dividing this number by the number of holes in the rim, viz., thirty-six, we get twenty complete revolutions per second, and since there are six spokes in the wheel, one spoke would follow its neighbor in front of the lens in $\frac{1}{120}$ of a second.

A second method, and the one employed on this occasion, was that of pressing into our service an old turnstile counting apparatus. This was attached to the axis of the revolving sector, and its index watched for a set time, say 10 seconds, the number read off and divided by 10 to give the number of revolutions per second.

Behind the sector wheel is seen the lens and camera arranged in the same plane with the other parts of the apparatus, having a special chamber in the rear, holding a metal drum five inches in diameter, extending transversely across the interior of the camera to its full width. The drum turns about a horizontal axis that is parallel to the slit in the spectroscope tube and perpen-

dicular to the optic axis of the line of the apparatus. One end of the axis projecting through the side of the camera has a pulley disk on the end. The cylinder may be seen through the broken portion of the camera. The camera lens is adjusted to throw a sharp image of the slit in the spectroscope, upon the center of the surface of the cylinder in the camera. The cylinder is covered with a strip of sensitive (*e. g.*, bromide) paper held in position by elastic bands.

In place of the cylinder of bromide paper a circular sensitized glass plate can be fixed in a vertical plane in the back of the camera and made to rotate or whirl at a given speed, the flashes of light through the slit impressing it in the shape of radial lines, their number determining the rapidity of the shutter.

If now light from the lantern passes through the slit lens, etc., on to the front of the revolving paper on the drum, it would trace on the paper a rectangle image of the same width and length as the slit, the vertical length depending upon the rate of the drum revolutions, *i. e.*, how much paper turned past the image of the slit. If the sector be set revolving, every time a spoke or bar came in front of the lens it would cut off the light while it was passing. On developing the paper we should have a dark rectangle crossed by bars of light corresponding to the transits of the spokes. Suppose now the shutter to be of that form which causes a rectangular opening to pass in front of the lens. As the beginning of the opening was commencing to travel across the slit we should get an image of a portion only of the slit formed on the front of the revolving drum, and similarly as the opening commenced to close it would cut off more and more light from the slit, and so on, the image dwindling from a line to a point.

In Fig. 403 we have some such result. If we suppose the drum and sector to be stationary, we should get an image of the slit as a straight line as H_1 H_2. If the drum revolved and the sector was stationary, this straight line would be drawn out into a rectangle. If the sectors revolved, we should find this interspaced with clear parts, but suppose the shutters to commence slowly opening at the end H_1, and go on until the whole slit H_1 H_2 were fully covered by light for a time and then begin to close up again from H_1 toward H_2, the sector and drum revolving at the time, we should have some such figure as N M K L. The triangular part, M M′ N, corresponding to the time the shutter took to get fully open, the rectangular part, M M′ L L′, being the time that it remained fully open, and the triangular part, L L′ K, the period of closing. On further examing this diagram we note two complete bar spaces, and a little portion outside each, together equal to about that between two clear spaces. If now the sector were revolving at the rate above supposed and described, *i. e.*, $\frac{1}{120}$ second between each bar space, we should say that the shutter took then something between two and three such intervals to open, say $\frac{1}{60}$ to $\frac{1}{40}$ second to get fully open; remained fully open about two spaces, *i. e.*, say, $\frac{1}{60}$, and closed in a little more than one space, $\frac{1}{120}$ to $\frac{1}{100}$ second. The ideal or theoretical perfect shutter is one which takes no time to become fully open and to close as quickly, but as this is as yet not a practical thing, we have to accept this as a mental conception, and compare the actual performance of any shutter with it by contrasting its practical efficiency with its theoretically possible efficiency; we thus need but compare the area, M M′ L L′, *i. e.*, the period of full opening, with the corresponding area, N N′ K K′, *i. e.*, the base, N K′, with base, L M′.

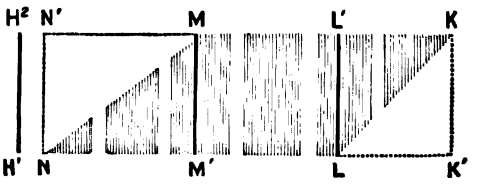


FIG. 403.

In Fig. 404 we have two other diagrams yielded by shutters opening and closing at the center. The areas inclosed by the dotted lines correspond to the ideal unit of efficiency. We can see at a glance that the A shutter is much more efficient than the other, *i. e.*, B form, which latter takes quite a comparatively long time to open as compared with the time it is fully open, but closes quicker than it opens. Examination of many shutters has led the lecturer to the conclusion that very few of them had more than about 65 per cent. efficiency.

When working the apparatus as above described, when the speed of the sectors and bars was a knowable quantity, there was no necessity to measure the speed of the revolving drum. All that was required was a fairly steady motion, and that it be fast enough. This the lecturer easily attained for the demonstrated experiments by revolving the projected axis by means of the fingers or a piece of string in the same way that one may cause a top to spin. If, however, the measuring of the speed of the sectors be a difficulty or objection, the following device may be substituted: a vibrating (tuning) fork of known frequency has attached to one of its arms a small reflecting mirror, which throws an independent point of light through the lens on to the face of the drum. When the fork is made to vibrate and the drum to revolve, the light from the small reflector traces a wave curve, and since the frequency of the fork's vibrations are known, this wave curve forms a time scale alongside the slit diagram.

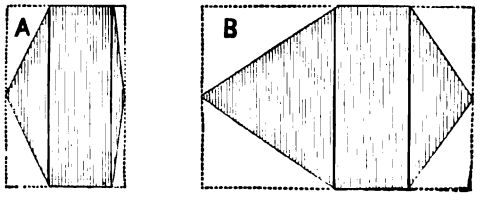


FIG. 404.

Numerous examples were shown and explained, one especially demanding mention being that of a shutter which, when set at a rather low speed, gave a fairly satisfactory record of its performances, but when set at higher speed clearly betrayed the fact that it rebounded to such an extent that a slight secondary exposure was made. Under such circumstances obviously it would not be likely to yield satisfactory negatives. This shutter acted satisfactorily at about $\frac{1}{35}$ second, but when its speed was about $\frac{1}{60}$ or $\frac{1}{70}$ the rebound exposure rendered it useless. A drop shutter, with elastic band, giving an exposure from start to finish of about $\frac{1}{100}$ second, yielded a diagram similar in shape to that in Fig. 403. but the time during which it was fully open was only about $\frac{1}{300}$ second. Generally speaking, the smaller the stop, the higher the efficiency.

The following notes on instantaneous shutters*, by Capt. W. De W. Abney, C.B., will be of interest. He says: "Perhaps on no pieces of practical apparatus have more labor and thought been expended than on instantaneous shutters. They are often constructed on very beautiful and ingenious designs; but, in many, something is wanting, and they are often far from what we may call ideal shutters, whilst others are as nearly perfection as may be.

The first question is as to the best position that the shutter should occupy. It is evident it may be on the front of the lens, at the back of the lens, or occupy a position close to the diaphragm; or, again, it may be placed close to the plate. Let us see what these several positions entail in regard to the general exposure of the plate. We will suppose for the moment that the shutter is of a guillotine type, and that it falls from the top to the bottom, the exposure of the lens beginning first at the top, and finishing at the bottom. When it is in front of the lens, as the top part of the lens is that with which the image at the top of the picture is made, it is evident that the sky of a landscape is first exposed, then the middle distance, and finally the foreground near this base. Or let us take an example of the figure of a man moving across the view, and whose image occupies nearly the total height of the plate. The hat will be first exposed, then the face, next the trunk, and finally the legs, the last portion which is impressed being the feet. The photograph would not represent him in the position he occupied at any particular instant of time, but it would represent the position that his hat occupied at one instant, his face at another, and so on. Suppose the guillotine was a fairly narrow slit, which moved downward at a moderate rate, it is evident that the movement of any small portion of the image would be small during exposure, though the motions gone through between the time the hat and the feet were exposed might be large. In fact, it might happen that the image on the plate would show the man as tumbling backward, and the relative position of the swinging arms to that of the legs actually reversed, and make the proportions of the figure absolutely untrue.

With the shutter at the back of the lens the attitude of the man would be reversed. It might show him as in the act of falling forward, for the image of his feet would be first exposed, and the hat last. Of course, these are exaggerated examples of the want of truth that might be exhibited, but they are possible.

With the shutter close to the plate the distortion is much more likely to be marked than in either of the above cases, for even with a guillotine shutter on the lens in which the slit is moderately narrow, the image seen through it at one instant includes more than that width, for, were this not so, the image would not be of bigger dimensions than the lens itself. With the shutter close to the plate, on the other hand, it is the width of the slit which determines the amount of image exposed. The accompanying silhouettes show what happens when a narrow slit passes across the plate. A is the image of a man actually photographed with a shutter at the diaphragm. At the proper distance from the lens this image was made to move at the rate a man would move, and exposure given to a plate, with a guillotine shutter next the plate, the slit being narrow. B is the photograph obtained of A when the figure was moved in the direction he faced; and C when the motion was in the reverse direction. B looks tumbling forward, while C looks tumbling backward.

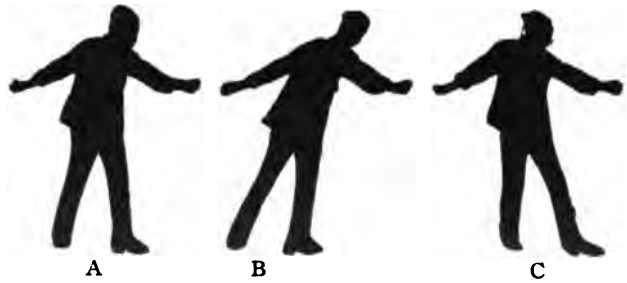


FIG. 405.

When the shutter is placed near the diaphragm the conditions are totally changed. The exposures for all parts of the image commence and finish together, and are of precisely the same duration. If it be necessary to give a certain exposure to an image, for satisfactory results, it is manifest that it does not matter theoretically whether the whole image is exposed for such time, or whether the different parts are exposed successively for the same time; but it matters a good deal practically, for the total time occupied in giving the successive exposures must necessarily be longer than that in which the exposures are given at the same time; and if the camera be held in the hand,

* From "Instantaneous Photography." Published by the Scovill & Adams Co. of New York.

the probability is that during the longer total of successive exposures a greater movement in the hands of the operator will be found than during the shorter and simultaneous exposure.

The accompanying cut shows the movement of a hand camera in a quarter of a second. The top line is the movement when held in both hands without any support; the second line shows the movement when held under the chin and above the chest. The third line shows practically no movement. In this case the camera was held in two hands, and supported on an umbrella handle. The lowest line shows the movement when held against the bottom of the chest, so that the beating of the heart and the breathing interfered with the steadiness. The writer cannot help thinking that the diagram is very instructive, and shows that practically perfect steadiness can be attained by the use of a support.

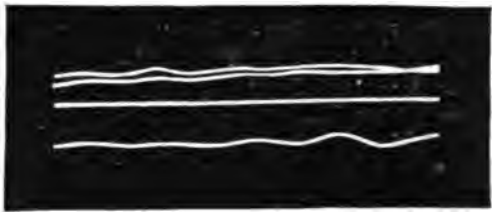


FIG. 406.

These records were obtained by fixing a vertical card, in which a pinhole was pierced, to the camera, and allowing the light from a stationary lamp to send a beam through the hole, the image of which was focused on a plate moving horizontally.

On the ground, then, that distortion, and also total time of exposure, is minimized when the shutter is placed at the diaphragm, the writer has come to the conclusion that practically that is the best position for it. Another point is this: that the movement necessary in the shutter itself is less in this than when in any other position, as the diameter of the diaphragm must ordinarily be smaller than that of the surface of the lens or plate itself.

Let us now consider as to the circumstances which favor the movement of a camera when held by the hand, owing to the release of the shutter. In the first place, it must be borne in mind that the camera and shutter are practically one structure, and that when the shutter is placed ready for exposure, the combination has its center of gravity in some one position. If, when the shutter is moving, the center of gravity shifts to another position, a movement, slight though it may be, must take place unless the camera be rigidly supported. There are two ways of meeting this difficulty; one is to make the motion of the shutter symmetrical on each side of the lens (in other words, to close to the center); and the other is to make the movable parts of the shutter as light as possible compared with the camera. Now, most shutters are light, but there are many which do not close centrally, and, in fact, as we shall see shortly, such a method of closing is detrimental, except when it is placed at the diaphragm. Another point is, that the release of the shutter should be as light as possible, and should not be by a push or pull, but by a *pressure*. All rifle shots know that the sights of a rifle are invariably moved from the mark if the trigger is pulled, whereas when a pressure is applied between the thumb and finger this does not obtain. The release, then, should be by a pressure, and all other methods should be avoided. With the pneumatic arrangement, of course, this does not apply, for the release is then given by an apparatus which is not rigidly attached to the camera. For hand-cameras, however, the pneumatic release is inconvenient, though it can be effected by inflating the tube by the mouth instead of by pressure with the hand.

As regards the efficiency of a shutter, the question is as to how it is to be judged. It is not difficult to understand, if we have two shutters, both of which give the same total duration of exposure, that if one leaves the full aperture of the lens uncovered for double the time that the other does, the first one will allow a greater quantity of light to reach the plate, and will, therefore, be more efficient than the second. In other words, the efficiency of a shutter depends on the ratio of the time during which the plate, or part of the plate, receives the light coming through the full aperture, to that of opening and closing. Perfect efficiency, of course, would be when the time of opening and closing is *nil*, and the full aperture is used throughout. If this theoretic efficiency could be secured, it is manifest that it would be immaterial whether the shutter were at the back, the front, or in the center of the lens. In comparing the efficiency of one shutter with another, the standard that is taken as unity is the theoretical shutter, but every part of the plate has to be considered, unless the shutter be placed at the diaphragm. What we have to determine, then, is the aperture uncovered during every small interval of time, to add these apertures together, and divide by the total duration of exposure, and compare it directly with the full aperture. Thus, suppose the total duration of the exposure was the $\frac{1}{10}$ second, that

At the $\frac{1}{100}$ of a second, $\frac{1}{10}$ of the area of the aperture was uncovered.
At the $\frac{2}{100}$ of a second, $\frac{1}{5}$ of the area of the aperture was uncovered.
At the $\frac{3}{100}$ of a second, $\frac{1}{2}$ of the area of the aperture was uncovered.
At the $\frac{4}{100}$ to the $\frac{6}{100}$, the whole aperture was uncovered.
At the $\frac{7}{100}$ of a second, $\frac{1}{2}$ of the aperture was uncovered.
At the $\frac{8}{100}$ of a second, $\frac{1}{5}$ of the aperture was uncovered.
At the $\frac{9}{100}$ of a second, $\frac{1}{10}$ of the aperture was uncovered.

The efficiency would be $(\frac{1}{10} + \frac{1}{5} + \frac{1}{2})\ 2 + 3$, or $6\frac{2}{5}$ approximately, whilst the theoretical perfect efficiency would be 10. The relative efficiency would be $\frac{6\frac{2}{5}}{10}$, or .64. If the areas uncovered for

another shutter of the same speed were respectively $\frac{1}{30}$, $\frac{1}{10}$, $\frac{1}{5}$, $\frac{1}{2}$, 1, $\frac{1}{2}$, $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{30}$, the efficiency would be only .27.

If a plate, therefore, with the first shutter was just enough exposed, with the second it would be greatly under-exposed.

SIDEREAL PHOTOGRAPHY.—See **Astronomical Photography.**

SIDE SWING.—An arrangement by means of which the back of the camera carrying the focusing glass and dark slide can be moved, so that one side be nearer or farther from the lens than the other. In the double swing back, besides the vertical swing explained under **Swing Back**, there is also an arrangement for its movement horizontally, so that the proper focus may be secured of any object, whether at top, bottom, or at either side of the image.

SILHOUETTES.—These can be made very effectively by photography to represent the old style of profile portraits cut out of black paper. One method is to place the sitter against a white translucent screen brightly illuminated from behind, giving a short exposure and strong development; or the sitter can also be placed behind and near to the screen, his shadow being photographed. A simple method of making a silhouette portrait from an ordinary side-face negative is to print a light positive on albumenized paper and carefully cut out the figure. This is then placed in the light to get quite dark, and then toned a deep black, fixed and pasted on to a white mount. To save the trouble of the last operations the cut-out portrait can be dipped in ink, or otherwise blackened. Other methods of obtaining these portraits will no doubt suggest themselves. What is required is a perfectly sharp outline of the features taken to give as correct likeness as possible. A study of the old-fashioned cut-out portraits is advisable.

FIG. 407.—TRIPLEX SHUTTER, EXTERIOR.

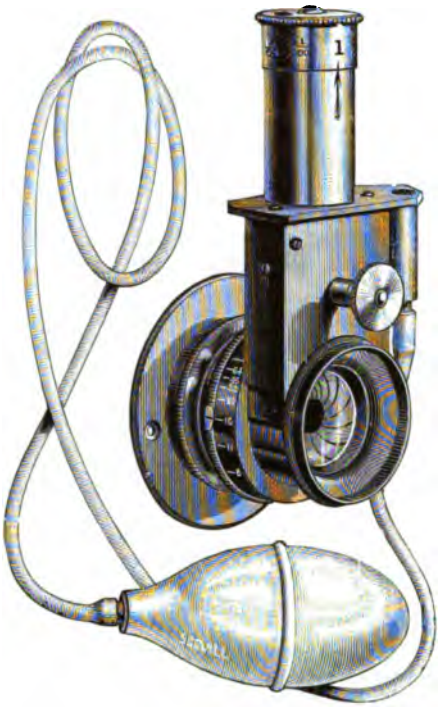


FIG. 408.—DIAPHRAGM SHUTTER.

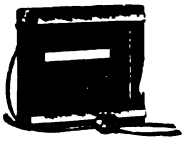


FIG. 409.—THORNTON PICKARD FOCAL PLANE SHUTTER.

FIG. 410.—THORNTON PICKARD BLIND SHUTTER.

FIG. 411.—TRIPLEX SHUTTER, INTERIOR.

SILK, PRINTING ON.—Photographic positives can be made very effective printed upon silk, satin, or other fabrics. There are several methods of accomplishing this. A simple one is the following: The silk best suited for the purpose is that known as Chinese silk, and this is first washed in warm water with a plentiful lather of soap, then rinse in hot water, and gradually cool until the final washing water is quite cold. Next prepare the following solutions:

SOLUTION 1.

Tannin	4 parts
Distilled water	100 parts

SOLUTION 2.

Sodium chloride	4 parts
Arrowroot	4 parts
Acetic acid	12 parts
Distilled water	100 parts

The arrowroot is mixed up into a paste with a little of the distilled water, and the remainder added boiling hot, with the acid and the salt previously dissolved in it. When the solution is quite clear the tannin solution is added, and the whole allowed to get fairly cool. The silk is then immersed for about three minutes, being kept under without air in the folds, and then hung up to dry, or stretched out with pins on a flat board. The material is then sensitized by brushing over with the following solution:

Silver nitrate	12 parts
Distilled water	100 parts

Nitric acid, two drops to every three ounces.

Other methods of sensitizing are by immersing in or floating on the silver solution. After sensitizing, the material is dried by pinning on to a board to keep flat. It is then cut up as required, and printed behind the negative. Every care must be taken in printing to keep the material flat, and withont wrinkles or folds. It must also be kept quite straight, otherwise the image will be distorted. Printing is carried on in the same manner as with albumenized paper. It is then washed and toned in any toning bath. The sulphocyanide gives the best action. Fix in a ten per cent. solution of hyposulphite of soda for ten minutes, wash and dry spontaneously. When just damp it is ironed out flat with a not over-heated iron. Black tones can be obtained with a platinum toning bath, or with the uranium and gold toning bath made up as follows:

Gold chloride	1 part
Uranium nitrate	1 part

Dissolved and neutralized with sodium carbonate, and then added to

Sodium chloride	16 parts
Sodium acetate	16 parts
Sodium phosphate	16 parts
Distilled water	4,000 parts

Very effective results may be made by printing with wide white margins obtained by exposing with a non-actinic mask.

Another method is the following :

Ammonium chloride	100 grains
Iceland moss	60 grains
Water (boiling)	20 ounces

When nearly cold this is filtered, and the silk immersed in it for about fifteen minutes. To sensitize immerse the silk in a 20 grain solution of silver nitrate for about sixteen minutes. The silver solution should be rather acid.

Or immerse the silk in—

Water	1 ounce
Sodium chloride	5 grains
Gelatine	5 grains

When dry float for thirty seconds on a 50-grain solution of silver nitrate. Dry, slightly over-print, and tone in the following bath :—

Gold chloride	4 grains.
Sodium acetate	2 drachms.
Water	29 ounces.

Keep twenty-four hours before using. Fix for twenty minutes in hypo, 4 ounces to the pint of water.

Images in many different dyes may be made upon silk by the Diazotype process. (See **Primuline Process.**)

Instead of silk, satins and other similar fabrics can be used.

SILVER (Symbol, Ag; atomic weight, 108).—A white metal which when quite pure is rather softer than gold, and not quite so soft as lead. It is the best known conductor of both heat and electricity. Its great use in photography is due to the fact that it forms compounds exceedingly sensitive to light.

In consequence of its softness all silver for the manufacture of coins and articles is mixed with copper; American coinage contains 10.13½ parts of pure silver in 12 parts. The following method of obtaining pure silver from coins is given by Wall: Place the coin, either entire or, preferably, cut up small, in a test tube, with one part of pure nitric acid and two parts of water;

apply a gentle heat, and an action commences at once, orange-red fumes of nitric oxide being evolved. If after the lapse of some time the whole of the coin is not dissolved, add more nitric acid, and again apply heat. When the coin is dissolved, the solution will be seen to be of a bright blue color, due to the copper; pure silver can be obtained from this solution by evaporating to dryness and fusing strongly the resulting mass. A little taken out and dissolved in water should give no blue coloration with solution of ammonia; or sheet copper may be placed in the acid solution, when a precipitate of pure silver will take place, which may be collected and again dissolved in nitric acid to form solution of nitrate of silver; or the precipitate may be collected and fused as above to obtain a button of silver. An United States dollar contains 370 grains of pure silver and 30 parts of alloy.

Silver is soluble in nitric acid and boiling sulphuric acid, and partially in hydrochloric acid, and combines directly with chlorine, bromine, and iodine.

Water at ordinary temperature, and air free from sulphuretted hydrogen, have no effect upon it, tarnishing being due to the sulphuretted hydrogen contained in the air.

Silver is principally employed in photography in the manufacture of silver nitrate (*q.v.*).

TABLE OF THE LIGHT SENSITIVENESS OF VARIOUS SILVER COMPOUNDS

(Marktanner—Turneretscher).

v. i. — very intense; i. — intense; t. i. — tolerably intense; m. i. — moderately intense; s. i. slightly intense; n. i. — not intense.

	I. With Excess of Silver.				II. With Excess of Salt.				
Name.	A. Without Ammonia fuming.		B. With Ammonia fuming.		A. Without Ammonia fuming.		B. With Ammonia fuming.		Remarks.
Chemical Formula (Solubility).	Sensitiveness of AgCl = 100.	Color and Intensity.	Sensitiveness of AgCl = 100.	Color and Intensity.	Sensitiveness of AgCl = 100.	Color and Intensity.	Sensitiveness of AgCl = 100.	Color and Intensity.	
1. Silver Chloride: AgCl (insol.)	100	blue black, v. i.	100	blue black, more intense than without fuming	80	violet, v. i.	100	violet, v. i.	With excess of salt, although very intense, still less so than with excess of silver.
2. Silver Bromide: AgBr (insol.)	700	bluish gray, n. i.	900	bluish gray, n. i.	250	bluish gray, n. i.	300	bluish gray, n. i.	Scarcely more intense with fuming than without.
3. Silver Iodide: AgI (insol.)	300	greenish gray, n. i.	450	reddish gray, n. i.	40	yellowish gray, n. i.	75	yellowish gray, n. i.	Fuming scarcely increases the intensity.
4. Silver Chloride: AgCl; excess of silver nitrate removed by washing.	95	violet, with red tinge, v. i.	100	violet, with a red tinge, v. i.	—	—	—	—	Less intense than No. 1, the normal paper: scarcely more intense with fuming.
5. Silver Chloride: AgCl treated as in 4; and then floated on KNO_3 solution.	80	Intense, very nearly equal to the normal, No. 1.	130	Intense, equal to normal No. 1.	—	—	—	—	Paper prepared according to Abney's process.
6. Silver Chloride: AgCl, prepared as No. 5, but Sodium Sulphite used.	100	violet, v. i.	100	violet, v. i.	—	—	—	—	The papers attain nearly the very same intensity as the normal paper, but more intense than the merely washed paper.
7. Silver Nitrate: $AgNO_3$.	6	reddish, n. i.	8	reddish, n. i.	—	—	—	—	Silver nitrate alone does not become colored only in the presence of organic substances,
8. Silver Albuminate without Silver Chloride.	13	red, s. i.	30	bluish, s. i.	—	—	—	—	The paper was prepared by floating on beaten albumen and then silvering.
9. Sensitized Paper, freshly prepared.	50	purple brown, v. i.	60	purple brown, uncom. i.	—	—	—	—	So-called "Rosa brilliant papier" was used.
10. Sensitized Paper, commercial.	70	purple brown, v. i.	80	purple brown, v. i.	—	—	—	—	
11. Gelatino-bromide Plate.	—	—	—	—	600	greenish gray, v. i.	—	—	
12. Formiate: $AgCHO_2$.	—	—	—	—	—	—	—	—	The sensitized papers turn brown even in an absolutely dark room.
13. Acetate: $AgC_2H_3O_2$ (1 : 97).	6	yellowish gray, s. i.	20	reddish gray, t. i.	4	yellowish gray, n. i.	15	reddish gray, s. i.	
14. Propionate: $AgC_3H_5O_2$ (1 : 119).	6	red brown, s. i.	10	yellow brown, s. i.	7	red brown, s. i.	15	yellow brown, s. i.	
15. Normal Butyrate: $AgCH_3(CH_2)_2CO_2$ (1 : 200).	8	reddish yellow, m. i.	22	red brown, m. i.	10	reddish gray, m. i.	20	gray brown, m. i.	Color somewhat more intense than with isobutyrate.
16. Isobutyrate: $(CH_3)_2$—$CHCO_2Ag$ (1 : 108).	7	yellowish red, n. i.	18	brownish, s. i.	6	reddish brown, s. i.	18	red brown, s. i.	Color somewhat less intense than with the salt of the normal acid.
17. Valerianate: $Ag(CH_3)_2CHCH_2CO_2$ (1 : 540).	8	violet brown, m. i.	14	reddish gray, t. i.	14	reddish gray, m. i.	30	gray brown, t. i.	
18. Caproate: $AgC_6H_{11}O_2$ (sol. with great difficulty).	9	gray, m. i.	15	gray, m. i.	14	reddish brown, t. i.	24	gray, t. i.	

TABLE OF THE LIGHT SENSITIVENESS OF VARIOUS SILVER COMPOUNDS.—*Continued.*

19. Œnanthyeate: $AgC_7H_{13}O_2$ (sol. with difficulty).	10	brown violet, t. i.	14	gray violet, t. i.	14	brown violet, t. i.	16	gray brown, i.	
20. Caprylate: $AgC_8H_{15}O_2$ (scarcely soluble).	12	gray, s. i.	5	gray, n. i.	17	reddish brown, t. i.	6	gray brown, s. i.	
21. Œnanthate: $AgC_7H_{17}O_2$ (insol. in cold water).	25	first of all red, then gray, t. i.	30	gray, t. i.	20	first red, then gray, t. i.	25	brown, s. i.	
22. Rutate: $AgC_{10}H_{19}O_2$ (insol.).	5	brown violet, s. i.	6	reddish gray, n. i.	14	reddish brown, t. i.	18	reddish gray, t. i.	The papers remained white for several weeks when kept in the dark.
23. Palmitate: $AgC_{16}H_{31}O_2$ (insol.).	5	yellowish, n. i.	6	yellowish gray, n. i.	3	yellowish, n. i.	8	yellowish gray, n. i.	The solution of salt was $\frac{1}{10}$ normal.
24. Stearate: $AgC_{18}H_{35}O_2$ (insol.).	14	gray, n. i.	22	gray, n. i.	—	—	—	—	Solution of the salt $\frac{1}{2}$ normal.
25. Certotate: $AgCH_3(CH_2)_{25}CO_2$ (insol.).	1	yellowish gray, s. i.	5	yellowish, n. i.	2	yellowish, n. i.	5	yellowish, n. i.	The solution of the salt was $\frac{1}{10}$ normal.
26. Oleate: $AgC_{18}H_{33}COO$.	10	reddish gray, s. i.	11	greenish gray, s. i.	9	reddish gray, s. i.	6	gray, s i.	The solution of salt was $\frac{1}{2}$ normal.
27. Glycolate: $AgCH_2OH_2COO$ (sol. with difficulty).	6	reddish yellow, s. i.	11	brownish, s. i.	4	yellowish gray, n. i.	7	brownish, n. i.	
28. Lactate: $AgCH_3CHOHOCO$ (1 : 20).	8	yellow red, t. i	16	yellow red, t. i.	17	rusty yellow, t. i.	18	gray, t. i.	Alcohol was used on account of the difficulty of dissolving the salt.
29. Paralactate: $AgCH_2CHOHCOO$.	7	yellowish red, t i.	17	yellow red, t. i.	17	rusty yellow to brown, t. i.	17	gray brown, t. i.	The paper prepared with excess of salt was rather more intense than with excess of silver.
30. Oxalate: $Ag_2C_2O_4$(insol.).	2	reddish, n. i.	80	red brown, s i.	20	dark brown, i.	70	dark brown, v. i.	
31. Malonate: $AG_2CH_2(COO)_2$ (sol. with difficulty).	4	reddish gray, s. i.	8	gray, t. i.	5	reddish yellow, s. i.	13	reddish brown, t. i.	
32. Malate: $Ag_2C_2H_3OH(COO)_2$ (sol. in hot water).	2	red brown, i.	18	gray brown, i.	7	red brown, i.	13	red brown, s. i.	
33. Tartrate: $Ag_2C_4H_4O_6$.	7	red brown, i.	17	red brown, i.	9	reddish brown, t. i.	24	red brown, s. i.	
34. Citrate: $Ag_3C_3H_5O_7$ (sol. in boiling water).	15	gray brown, m. i.	18	red brown, i.	6	brown, m. i.	12	gray brown, i.	
35. Hippurate: $CH_2{}^{NHC_7H_5O}_{COOAg}$.	12	rusty brown, t. i.	24	gray brown, t. i.	16	rusty brown, t. i.	50	gray brown, t. i.	

SILVER ALBUMINATE (Synonym, *albuminate of silver*).—This name is given to a white insoluble substance formed when albumen is mixed with silver nitrate. Its composition is very uncertain. It reddens on exposure to light. It is formed when albumenized paper is sensitized in a silver nitrate solution.

SILVER AMMONIO-NITRATE (Formula, $Ag\,NO_3{}^{2}NH_3$; synonym, *ammonio-nitrate of silver*).—Can be obtained by exposing powdered silver nitrate to ammoniacal gas. Combination takes place rapidly. Solutions of ammonio-nitrate of silver are used in sensitizing plain salted paper for positive printing, and also in the manufacture of gelatino-bromide of silver emulsion by the ammonia process.

SILVER BATH (for paper).—In the ordinary method of making photograph positives by what is termed silver printing, paper prepared with albumen or gelatine containing a certain quantity of a soluble chloride is floated for varying lengths of time on what is termed a "silver bath." It consists of a solution of silver nitrate with or without the addition of other substances. Upon floating on this solution a certain quantity of it is absorbed by the gelatine or albumen substratum, and combines with the chloride to form silver chloride in a very fine state of division. The effect of the light upon the white surface of the silver chloride is to darken it to a violet color. The action of the light may be stated to be quite superficial, for even if the action of the light be allowed to continue until the color is very deep the amount of reduced silver forming it is exceedingly small. It will be obvious that an important consideration is the strength and composition of the silver bath in order to secure the best results. It will naturally be imagined by the student that the strong bath would sensitize the paper much quicker than a weaker solution, but this is not the case, however. Again, it would be natural to suppose that with a weak bath the paper would take up less silver than with a strong bath. This is also incorrect. A certain quantity of silver nitrate will combine with the chloride and organic substances used in preparing the paper no matter whether the bath be weak or strong.

A strong solution of silver has the effect of hardening the albumen surface, so that for a time there is repulsion between the paper and the bath solution; while the weaker solution not

affecting the albumen in this way is readily absorbed, and if the floating of the paper be long continued the solution will penetrate the albumen and dissolve it.*

In both these methods of floating, either for a long time on a strong bath, or for a short time upon a weak one, we obtain serious disadvantages. In the first case, although we get brilliancy in the positives, the bronzing of the shadows is with some negatives a serious defect; and in the second method the prints are usually very weak with a poor sunken-in appearance

For general use, a bath of medium strength, 40 grains of silver nitrate to the fluid ounce of water, is the best, as it is suitable for most work, least likely to get out of order, and can be easily kept a required strength.

Silver baths may be divided according to their composition into three classes.†

The first class comprises such formulæ which require the use of nitrate of silver and water only. They usually differ in strength from between 40 to 60 grains of silver nitrate to the ounce of water. It should be kept slightly alkaline in reaction by the occasional addition of a few drops of ammonia or a small quantity of a strong solution of sodic carbonate. A small quantity of silver carbonate will be formed with the addition of the latter solution, but this will settle to the bottom, and tend to keep the bath clear by carrying down with it any floating organic matters.

The second class refers to the old ammonio-nitrate method formerly much used, and still largely, for the production of silver prints upon plain paper. It is prepared as follows: The silver nitrate is first dissolved in the requisite quantity of water, two thirds of the solution are then placed in a separate vessel, and strong ammonia added drop by drop. A precipitate of oxide of silver is at once formed, and the ammonia still added in drops until this precipitate is completely dissolved again. The remaining third of the solution is then added, when a slight precipitate will be again formed. This is removed by adding pure concentrated nitric acid very cautiously drop by drop until the precipitate is just re-dissolved, not another drop being put in after that. Although this bath gives greater sensibility to the paper, and deeper prints, yet it is more likely to discolor owing to the separation of organic matter from the paper.

The third class of silver baths includes those which in addition to the silver nitrate contain alkaline nitrate, such as the ammonium, sodium, or potassium salts. The action of these salts is to absorb the free chlorine, and further to prevent the paper from becoming too dry in very hot weather. There are a great variety of formulæ, one of the most generally used is—

Silver nitrate	50 grains
Ammonium nitrate	30 grains
Water	1 ounce

Made slightly alkaline with the addition of ammonia or sodium carbonate. A few grains of alum are also added sometimes, for preventing blisters.

In sensitizing albumen or plain salted papers upon the silver bath they are always floated. For full instructions see **Sensitizing.**

The strength of the silver baths should always be greater in the winter and less in the summer.

Never attempt to use the smallest possible amount of solution. The depth in the bath should be at least half an inch.

Considerable care and attention must be taken in the preparation and care of the silver bath. It must be remembered that each sheet of paper floated upon the solution absorbs a quantity of the silver, and unless this be replaced the bath will soon refuse to work. For strengthening the solution, a stock solution of 60 grains of silver nitrate to the ounce of distilled water. A practice adopted by some operators is to allow about 50 grains of silver nitrate for each sheet of paper, and the amount of silver corresponding to the number of sheets used is dissolved in a few drachms of distilled water and added to the bath.

With regard to the water used in making up a strengthening silver bath, there is no doubt that distilled is the best; ordinary cistern water can, however, be used if the solution be exposed in a clear glass vessel to the sun or bright daylight. It will then become quite brown, owing to a precipitate formed, which will, however, fall in a few hours to the bottom of the vessel, when the clear liquid can be poured off and filtered.

The alkalinity of the bath should not be too decided. When it shows an acid reaction a few drops of a diluted solution of ammonia are added until the red litmus paper *slowly* changes to blue.

Some operators prefer to use an acid bath acidified with citric acid. This is useful when the paper is required to be kept for some days, but otherwise it is not recommendable, because the results are not so fine, the action is slower, and the bath is not so easily purified.

The usual method of determining the strength of the silver solution is by means of the hydrometer or argentometer, the latter being specially marked, showing at a glance the number of grains of silver nitrate in each ounce of the solution. With pure solutions of silver nitrate the strength can be correctly estimated, but after a time the bath becomes contaminated with soluble salts, organic matter, etc., which tend to increase the density of the solution, and to render the

* Heighway's "Printer's Assistant." † C. L. Mitchell, M.D.

working of the argentometer less accurate. The principal source of contamination to the solution is from the dissolution of the albumen from the paper floated on it. This, in time, causes the bath to become yellow and then brown. This discoloration must, of course, be removed, otherwise the paper will be unevenly sensitized and darkened.

There are several methods of purifying the bath. A simple one is to add a little kaolin, and then shake it up well and place in glass vessel in the sun. The organic matter is carried down with the kaolin as it subsides. It is then filtered and is ready for use. Kaolin is the purest form of disintegrated felspar; it sometimes contains chalk, which renders it unfit for decolorizing acid solutions of silver citrate. It should then be treated with a weak acid and washed.

Another method of purifying the bath is by the addition of a little of a strong solution of potassium permanganate. A stock solution is made up of—

Potassium permanganate.....	20 grains.
Water.....	1 ounce.

The usual method after the paper has been all sensitized for the day is to add a few drops of this solution with a glass rod, and stirring up the bath to well mix it. The solution takes a rose tint, which gradually dies out; a few more drops are added until the rose color does not die away. The tinted solution is then put into a clean glass bottle and exposed to sunlight until the color disappears. It is then filtered until clear. With a few drops of the permanganate solution, the bath can be decolorizing during the sensitizing operations by well mixing it up. It must be used with caution, however, as evil effects can also arise from it.

Other methods consist in adding a few drops of hydrochloric acid or a pinch of common salt. Chloride of silver is instantly formed, which falls to the bottom, carrying impurities with it, or a small quantity of sodium carbonate can be added, and the bottle placed in strong sunlight.

When any of these methods fail, however, it can be restored by "boiling" the bath. The solution is poured into an enameled iron dish placed over a lighted gas stove. If the bath is not alkaline it must be made so by the addition of ammonia solution. When thoroughly heated it will become black and turbid. When about a third of the solution has evaporated the solution is cooled and filtered. The strength of the silver is then ascertained, and distilled water added to reduce it to the required strength. Another method is to fuse the bath. The method is similar to the last one. The evaporation is continued to dryness, and the bath fused until all frothiness disappears. The heating apparatus is then removed, and the mass scooped in a lump. When sufficiently cool sufficient of a nitric acid solution 1 in 12 is added to re-dissolve the silver with the aid of heat. The bath is again evaporated to dryness, dissolved in pure distilled water, and filtered water is then added until correct strength is obtained, all organic matter having been by this means thoroughly carbonized.

It will often happen that the silver solution becomes so choked up with the soluble salts, resulting from the chemical actions which occur in sensitizing, that none of the methods of purification will be advantageous. In this case it is best put away and the silver recovered at a convenient opportunity. Mr. C. L. Mitchell gives the following methods of recovering the silver from the old baths:—If the bath had been made according to the first or third class, all that is necessary is to render the bath acid with nitric acid, and then add a strong solution of washing soda until the white precipitate of carbonate ceases to be formed. This is allowed to settle, the supernatant liquid poured off, and the precipitate washed repeatedly until the washings are free from color, and all soluble salts have been removed. The precipitate is then drained on a filter and the moist mass filtered, and all is placed in a dish of porcelain or enameled iron, and dilute nitric acid (1 in 10 of water) added, until effervescence ceases, and the white precipitate is nearly entirely dissolved. This solution is then filtered and evaporated, first to dryness, and then heated to calm fusion, and allowed to cool. The resulting semi-crystalline mass may be considered a pure silver nitrate. If the old silver bath, however, is prepared according to the ammonia-nitrate formula, this method will not answer, as in the presence of ammonia salt not all the carbonate of silver can be precipitated. The best plan, therefore, is to acidify the bath as before with nitric acid, and then add salt until all the silver is precipitated as chloride. This should be well washed, collected on a filter, and dried. It may then be converted into pure metallic silver by fusing it in a crucible with powdered charcoal and potassium nitrate, or it may be placed in a vessel containing dilute sulphuric acid (1 in 20) and metallic zinc added. Metallic silver will be precipitated in a finely divided state, and the zinc dissolved. From this silver the nitrate can be prepared by dissolving it in dilute nitric acid, and then proceeding in the same manner as described for the silver carbonate.

It should be noted that care and cleanliness will greatly assist in preserving the silver bath in its purity as long as possible. Filter and strengthen each time after using.

SILVER BATH FOR PLATES.—See under **Collodion, Wet Process.**

SILVER BROMIDE (Formula, AgBr.; molecular weight, 188; synonym, *bromide of silver*).—Prepared by direct union of the two elements silver and bromine, or by double decomposition between silver nitrate and any soluble bromide. In the Daguerreotype process, silver bromide is

formed by the first method, and in the dry-plate process by the second, potassium or ammonium bromide being used. When silver nitrate is added to potassium bromide, the silver combines with the bromide, and the nitrate with the potassium.

Silver bromide usually occurs in a yellowish state. Stas in his researches proves it to occur in six distinctly different states. These are—(1) as white flakes, (2) as yellow flakes, (3) as a bright yellow powder, (4) as a pearly white powder, (5) as a yellowish white powder, (6) in an intense yellow melted state.

Dr. Pitteurs classifies the photographically useful varieties of silver bromide as follows*:

		By Transmitted Light.	*By Reflected Light.*	*Photographic Occurrence.*
Semi-transparent.	Orange		Slaty blue	Very fresh collodion emulsions.
			Bluish-white	Ripened emulsion and wet collodion.
	Reddish orange		Bluish-white	Very sensitive wet collodion.
			Yellowish-white	Very old collodion emulsions.
Almost opaque...	Violet blue	Yellowish-white		Very old collodion emulsions.
		Greenish-yellow		Fresh gelatine emulsions.
		Green or Greenish-violet		Ripened gelatine emulsions.
	Blue	Indistinct		Red-sensitive gelatine emulsions, giving foggy pictures.

Silver bromide is insoluble in water, alcohol, ether, and in weak ammonia solution. Soluble in sodium hyposulphite, potassium cyanide, ammonia, and in saturated solutions of the majority of the chlorides, bromides, and iodides.

Bromide of silver is sensitive to light, darkening by a lengthy action to a dirty gray, bromine being evolved.

By very short exposures to light no visible change takes place, although a most important action in reality occurs. This action is usually stated to be a reduction to silver sub-bromide, Ag_2Br. Others consider it to be converted into an oxybromide $Ag_2O.2AgBr$, or into a photo salt† $AgBrz.yAg_2Br$. Whatever the precise action may be, it is a fact that it is more easily reduced by certain salts, alkaline pyro and other substances blackening it, which fact constitutes the process of development.

Its uses in photography, in the collodion and dry-plate emulsion processes, are very important.

SILVER CHLORIDE (Formula, AgCl; molecular weight, 143.5; synonyms, *chloride of silver, argentic chloride*).—A white insoluble substance obtainable by direct union between the two elements, chlorine and silver, or by double decomposition of silver nitrate with a soluble chloride. If a solution of sodium chloride or hydrochloric acid be added to a solution of silver nitrate, silver chloride is immediately formed as a white precipitate.

Silver chloride also occurs as a native ore, termed, from its peculiar appearance, horn silver.

Silver chloride when exposed to actinic light changes in color from white to purplish tints, and finally to black, but this only takes place if water, organic matter, or chlorine absorbents of some kind be present. If perfectly dry and pure no change takes place. Chloride of silver can be exposed to the light for years in a perfect vacuum without the slightest change taking place.‡ A certain quantity of humidity is necessary to form a reaction, hence in very cold weather the darkening of silver chloride paper is always slower than in warm and damp weather. By short exposure it becomes converted into what is generally considered to be sub-chloride of silver, the action being similar to that with silver bromide (*q.v.*), and can then be acted upon by reducing agents or developers, as they are termed.

Silver chloride is but slightly soluble in water, and in strong hydrochloric acid; potassium cyanide and sodium thiosulphate (hypo) dissolve it readily.

If fused silver chloride be covered with hydrochloric acid, and a piece of zinc placed upon it, it will be found entirely reduced after a few hours to a cake of metallic silver; the first portion of the silver having been reduced in contact with the zinc, and the remainder by the galvanic action set up by the contact of the two metals beneath the liquid.§

Ammonia will readily dissolve silver chloride, the solution depositing colorless crystals of the chloride when evaporated; if the ammonia solution is very strong, ammonia-chloride of silver will be formed.

Silver chloride melts at 260 deg. Fahr., is not decomposed if heated with carbon, but can be reduced by heating in a current of nascent hydrogen.

It is largely employed in photography for printing out processes owing to its darkening

* "Materia Photographica."—C. J. Leaper. † Carey Lea's Theory.
‡ Acunth has found that by heating silver chloride to a temperature of 220 deg. C., it passes into a modification that is insensitive to light.
§ Thomson and Bloxham's "Chemistry."

properties when affected by light, and in the manufacture of chloride and chloro-bromide emulsions by reason of properties it further possesses of being acted upon by certain developing agents, when exposed to light.

SILVER CITRATE (Formula, $Ag_3C_6H_5O_7$; molecular weight, 513; synonym, *citrate of silver*).—A white salt formed when a soluble citrate is added to silver nitrate. Silver citrate is capable of reduction by light, and for this reason sodium citrate is sometimes substituted for a portion of the salt in the salting bath of the albumen printing process. It reddens the color of the print, and makes the paper less sensitive, but, according to Hardwich, it renders it more vigorous on the surface, and less liable to assume a cold inky tint in the toning bath. Citrate of silver is also formed in the gelatino-citro-chloride and collodio-citro-chloride printing-out emulsion processes.

SILVER EMULSION.—An emulsion containing silver, usually in the form of an iodide, bromide, or chloride, or mixtures of these held in suspension in some viscous substance, as collodion, gelatine, etc.

SILVERING SOLUTION.—See **Silver Bath.**

SILVER INTENSIFICATION.—See under **Intensification.**

SILVER IODIDE (Formula, AgI; molecular weight, 235; synonym, *iodide of silver*).—Found in the mineral kingdom, but can be formed either by direct union between the two elements, silver and iodine, or by a double decomposition with silver nitrate and a soluble iodide. If silver nitrate be in excess the precipitate is of a strong yellow color, which darkens rapidly on exposure to light to a brown or greenish tint, but if the iodide is in excess no visible change takes place; the action of the light is then only visible by development, as with chloride and bromide of silver. It can be distinguished from silver chloride and bromide by its insolubility in ammonia or by its solubility in nitrate of silver solutions.

Silver iodide is insoluble in water, alcohol and dilute nitric acid, and nearly insoluble in strong ammonia. It is, however, soluble in all the solvents for silver bromide.

It is used in the Daguerreotype process, collodion process and in the manufacture of dry-plate emulsions. It gives extreme sensitiveness and greater density.

SILVER NITRATE (Formula, $AgNO_3$; molecular weight, 170; synonyms, *nitrate of silver, argentic nitrate, lunar caustic*).—Prepared by dissolving pure silver in nitric acid. Six ounces of silver are dissolved in 2½ fluid ounces of strong nitric acid and 10 fluid ounces of water, by the aid of gentle heat. The solution is then evaporated to dryness and heated to 198 deg. C. (fusing point) to expel excess of acid. Silver nitrate can also be prepared from standard silver, containing copper, in the following manner: Dissolve the metal in a moderately strong solution of nitric acid and evaporate in a porcelain dish. A blue residue, containing the nitrate of silver and copper, will be the result. The dish is then heated until this residue has fused and become uniformly black, the blue copper nitrate being decomposed, and leaving black copper oxide at a temperature which is insufficient to decompose the silver nitrate. Care should be taken that the residue is not heated more than sufficient to decompose all the copper nitrate. To find out when this is effected, take a little on the end of a glass and dissolve in water filtered and tested with ammonia. If any copper be present a blue color will be produced. When satisfactory, the residue is treated with hot water, the solution filtered from the copper oxide and evaporated to crystallization.

For surgical purposes the fused nitrate is moulded into thin sticks (lunar caustic), but for chemical and photographic purposes it is dissolved in water and crystallized. Silver nitrate acts as a powerful caustic, owing to the facility with which it parts with oxygen, the silver being reduced to the metallic state when in contact with organic matter. This effect is greatly increased by exposure to light. Pure silver nitrate undergoes no change when exposed to the light, but if organic matter be present a black deposit, containing finely-divided silver, is produced. It is for this reason that silver baths used for sensitizing collodion plates and albumenized paper readily become discolored. They can, however, be easily purified. (See **Silver Bath.**)

Re-crystallized silver nitrate should be soluble in its own weight of water and in four times its weight of boiling alcohol, which, however, precipitates it on cooling. Zinc, iron, lead, tin, and several other metals precipitate metallic silver from solutions of silver nitrate The following method of testing the purity of a commercial sample of silver nitrate is given by Clement J. Leaper: "Dissolve it in water; completely precipitate the silver with pure hydrochloric acid; filter and evaporate the filtrate to dryness, when no residue should remain. If there should be any remain, ignite it, when white fumes will indicate the presence of ammonium nitrate in the sample. If a residue remain after continued ignition, treat it with boiling water and test the soluble portion for potassium and sodium in the usual way (*vide* tests for these salts), when positive results will indicate the presence of potassium or of sodium nitrate. The insoluble portion left after treating the residue with water is dissolved in a little nitric acid diluted with

water and tested for lead with sulphuretted hydrogen, and for magnesium with ammonium hydroxide and sodium phosphate."

Silver nitrate is largely used in photography for a variety of purposes, but chiefly to form other silver salts. To prepare a pure solution of silver nitrate it is dissolved in water in a clean glass, bottled, and placed in the sun for a few hours. The solution will be rapidly darkened, and a brown precipitate will be formed. This will eventually fall to the bottom, and the clean solution may be decanted or filtered off. (See **Silver Bath.**)

To test the amount of silver nitrate in a solution, a special instrument, termed an argentometer, has been constructed. This is clearly marked with the number of grains per ounce. The following table, however, by Dawson,* will perhaps be found useful at times, when only an ordinary hydrometer is available. (See also under **Silver Tester.**)

TABLE FOR ASCERTAINING FROM THE SPECIFIC GRAVITY THE AMOUNT OF SILVER NITRATE CONTAINED IN ONE FLUID OUNCE OF ANY PURE SOLUTION AT 60° FAHRENHEIT.

GRS. PER FL. OZ	SP. GR.	GRS. PER FL. OZ.	SP. GR.	GRS. PER FL. OZ.	SP. GR.	GRS. PER FL. OZ.	SP. GR.	GRS. PER FL. OZ.	SP. GR.	GRS. PER FL. OZ.	SP. GR.
10	1,021	32	1,063	54	1,105	76	1,146	98	1,187	120	1,227
11	1,023	33	1,065	55	1,106	77	1,148	99	1,189	121	1,229
12	1,025	34	1,067	56	1,108	78	1,150	100	1,191	122	1,231
13	1,027	35	1,069	57	1,110	79	1,152	101	1,193	123	1,233
14	1,029	36	1,070	58	1,112	80	1,153	102	1,194	124	1,235
15	1,031	37	1,072	59	1,114	81	1,155	103	1,196	125	1,236
16	1,032	38	1,074	60	1,116	82	1,157	104	1,198	126	1,238
17	1,034	39	1,076	61	1,118	83	1,159	105	1,200	127	1,240
18	1,036	40	1,078	62	1,120	84	1,161	106	1,202	128	1,242
19	1,038	41	1,080	63	1,122	85	1,163	107	1,204	129	1,244
20	1,040	42	1,082	64	1,123	86	1,165	108	1,205	130	1,345
21	1,042	43	1,084	65	1,125	87	1,167	109	1,207	131	1,247
22	1,044	44	1,086	66	1,127	88	1,168	110	1,209	132	1,249
23	1,046	45	1,088	67	1,129	89	1,170	111	1,211	133	1,351
24	1,048	46	1,089	68	1,131	90	1,172	112	1,213	134	1,252
25	1,050	47	1,091	69	1,133	91	1,174	113	1,215	135	1,254
26	1,051	48	1,093	70	1,135	92	1,176	114	1,216	136	1,256
27	1,053	49	1,095	71	1,137	93	1,178	115	1,218	137	1,258
28	1,055	50	1,097	72	1,338	94	1,180	116	1,220	138	1,259
29	1,057	51	1,099	73	1,140	95	1,181	117	1,222	139	1,261
30	1,059	52	1,101	74	1,142	96	1,183	118	1,224	140	1,263
31	1,061	53	1,103	75	1,144	97	1,185	119	1,226		

Correction for Temperature.—For every 10° below 60° *deduct* one grain from the number quoted in the table, and for every 10° above 60° *add* one grain to the number tabulated.

SILVER NITRITE (Formula, $AgNO_2$). A brownish powder feebly soluble in cold but easily in hot water. It can be crystallized from a strong solution of silver nitrate saturated with ammonia. It is stated that a slight trace of it in the silver bath, used in the wet collodion process increases the sensitiveness. It is, however, liable to fog the image.

SILVER OXIDE (Formula Ag_2O; molecular weight, 232).—Obtained as a brown precipitate when a solution of silver nitrate is decomposed by potash. It is usually prepared by dissolving half an ounce of silver nitrate in four ounces of water, and pouring it into a bottle containing three pints and a half of lime water. The oxide is washed by decantation. It is a powerful oxidizing agent, and is used to purify silver solutions from copper.

SILVER PRINTING.—A term given to all methods of positive printing by means of silver chloride.

SILVER STAINS.—See **Stains.**

SILVER SUB-BROMIDE.—A hypothetical substance formed by the action of light upon silver bromide. (See **Silver Sub-salts.**)

SILVER SUB-CHLORIDE.—A hypothetical substance formed by the action of light upon silver chloride. (See **Silver Sub-salts.**)

SILVER SUB-IODIDE.—A hypothetical substance formed by the action of light upon silver iodide. (See **Silver Sub-salts.**)

* From Hardwich's "Dictionary of Photography."

SILVER SUB-SALTS.—Silver sub-chloride, sub-bromide, and sub-iodide, termed the sub-salts, are supposed by some to be formed when silver chloride, bromide, and iodide are exposed to the action of light. When, for instance, chloride of silver darkens by the light rays sub-chloride is supposed to be formed, thus—

$$4AgCl = 2Ag_2Cl + Cl_2$$

The sub-salt has, however, never been isolated in such a form as to correctly establish its chemical individuality.

The idea that the sub-chloride is the product of the photo-decomposition of the normal chloride was first suggested by Fische in 1814, was reiterated by Wetzlar, and has since received general acceptance.* Recent researches, however, appear to render the existence of these sub-salts extremely doubtful.

SILVER SULPHIDE (Formula, Ag_2S; molecular weight, 242).—Occurs in residue recovery, being the resultant salt of the decomposition of silver hyposulphite in the prints. It is insoluble in water or ammonia, but soluble in nitric acid, converting it into silver sulphate and nitrate.

SILVER SALTS, TESTS FOR.—Soluble silver salts give the following reactions:—With hydrochloric acid a white precipitate soluble in ammonia, with sulphuretted hydrogen a black precipitate, and with potassium chromate a brick red precipitate.

SILVER TESTER.—An apparatus for testing the quantity of silver nitrate in any solution pure or impure. For ordinary purposes the argentometer or hydrometer are usually used, the specific gravity of the liquid determining the amount of silver nitrate contained in it. When working with the silver bath in photographic processes, however, it gradually gets contaminated with other soluble matter, and the hydrometer test is no longer accurate for the amount of silver nitrate alone. Another method must therefore be employed. One much used abroad is Vogel's silver tester. (See fig. 412.)

It consists of a stand *S*, a burette *a*, two pipettes *p* and *F*, and a beaker glass *G*. A solution of iodide of potassium is prepared, containing 1023.4 cubic centimeters of water and exactly 10 grammes of pure dry iodide of potassium. 100 cubic centimeters of this solution precipitate 1 gramme of nitrate of silver, so that if one cubic centimeter of a silver solution is measured off and tested, every cubic centimeter of the test solution used gives 1 per cent. of nitrate of silver (1,000 cubic centimeters=2.11 pints and 1 gramme=15.4 grains). This prepared solution is placed in the burette *a*, which is divided off into cubic centimeters, and furnished with a pinch-cock *k*. The pipette *p* is then dipped in the silver solution to be tested, filled, by drawing with the mouth at the upper end, to the mark *i*, which is an exact cubic centimeter, and the solution allowed to run into the glass *G*. Into the same glass *G* are placed 1 or 2 cubic centimeters of prepared nitric acid, using the pipette *F*. (This nitric acid contains 1 grain of photosulphate of iron to every 2 ounces of pure acid). And finally 10 to 14 drops of a prepared starch solution are added. (This solution is made by rubbing up ⅛ oz. of starch to a thin paste with distilled water, pouring it into 12½ ounces of boiling distilled water, and stirring for several minutes; after settling for a few hours, the clear solution is poured off, and 2½ ounces of pure pulverized nitrate of potassium added, when it is ready for use, and will keep undecomposed for about six weeks.) The solution in the burette *a* is then allowed, by pressing open the pinch-cock, to run into the glass *G*, until the blue color which is produced does not disappear by shaking, but remains permanent. With a little care at the close of the testing, a single drop will be found sufficient to produce this permanent blue color. A simple reading of the number of cubic centimeters of solution used contains 7⅜ per cent., that is, 100 c. c. of solution contains 7⅜ grammes silver nitrate, which is equivalent to about 35 grains to the ounce.†

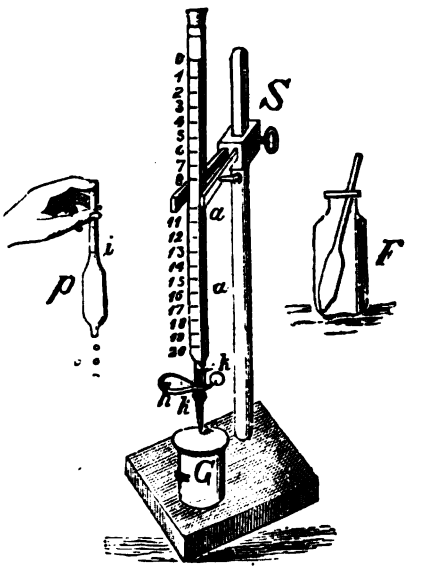


FIG 412.

Another method which, although not so accurate, is much simpler, is the following, the only articles required being an 8 oz. narrow-mouthed bottle, a graduated measuring glass, and some pure salt. The test solution is made by dissolving 55 grains of dried salt in a pint of distilled water. Pour into the 8 oz. bottle half an ounce of the silver solution to be tested, and add the testing solution gradually from a clean graduate measure, so that the quantity used can be accurately determined. After each addition shake the mixture well and add until no cloudiness is produced. If it requires one ounce of this solution, the silver solution contains 10 grains of

* Meldola's "Chemistry of Photography." † J. F. Magee.

silver nitrate to the ounce, if 2 oz. it contains 20 grains, and so also for fractional parts. 3½ oz. shows 31½ grains, and so 4½ oz. 45 grains, etc. As every one ounce of solution used shows 10 grains of silver nitrate to the ounce, it is only necessary to multiply the number of ounces and parts of an ounce to give the required result. If the silver solution contains ammonia after measuring off half an ounce of it into the 8 oz. bottle, it should be made acid with a little pure nitric acid, and then the operation can be proceeded with in the same way as before.

SILVERING MIRRORS.—See **Mirrors, Silvering.**

SIMPSONTYPE PROCESS.—The collodio-chloride printing-out process was first devised by G. Wharton Simpson, and termed Simpsontype.

SINGLE LENS.—See **Lens.**

SINGLE TRANSFER.—See **Carbon Process.**

SIZE.—The following list of photographic sizes may be found useful :—

SIZES OF GLASS MOUNTS, PAPER, &C.

Petite cards	1⅛ by 3½	Half-plate	4¼ by 6½ and 4½ by 5½
One-ninth plate	2 " 2⅝	Half-plate (English)	4⅝ " 6½
Lantern size	3¼ " 3¼	Whole plate (4—4)	6½ " 8½
One-sixth plate	3⅜ " 3¾	Extra 4—4	8 " 10
One-fourth plate	3¼ " 4¼		

Other sizes are expressed by inches.

SIZES OF FRENCH, GERMAN AND ITALIAN DRY PLATES WITH EQUIVALENT IN ENGLISH INCHES.

GERMAN AND FRENCH.							ITALIAN.						
Centimeters.				*Inches.*			*Centimeters.*				*Inches.*		
6½	by	9	=	2.5	by	3.7	9	by	12	=	3.7	by	4.7
9	"	12	=	3.7	"	4.7	12	"	16	=	4.7	"	6.3
12	"	15	=	4.7	"	5.9	12	"	18	=	4.7	"	5.9
13	"	18	=	5.1	"	7.0	13	"	18	=	5.1	"	7.0
12	"	20	=	4.7	"	7.8	12	"	20	=	4.7	"	7.8
15	"	21	=	5.9	"	8.2	18	"	24	=	7.0	"	9.4
15	"	22	=	5.9	"	8.6	21	"	27	=	8.2	"	10.6
18	"	24	=	7.0	"	9.4	24	"	30	=	9.4	"	11.8
21	"	27	=	8.2	"	10.6	27	"	33	=	10.6	"	12.9
24	"	30	=	9.4	"	11.8	30	"	36	=	11.8	"	14.1
27	"	33	=	10.6	"	12.9	40	"	50	=	15.7	"	19.6
27	"	35	=	10.6	"	13.7	50	"	60	=	19.6	"	23.6
30	"	40	=	11.8	"	15.7							
40	"	50	=	15.7	"	19.6							
50	"	60	=	19.6	"	23.6							

SIZES OF ALBUMEN PAPER.

18 × 22½, 20½ × 24½, 22 × 36, 26 × 40, 27 × 42.

For other sizes of paper see under **Paper.**

SIZE.—A gelatinous solution made by boiling the skin and membranous tissues of animals to a jelly, and used in paper-making.

SKIN.—A skin of gelatine made by pouring gelatine and glycerine on a glass plate, drying, and stripping. It is used in the stripping film process as a permanent support for the thin gelatine film holding the image. See **Stripping Film.**

SKY.—In landscape photography the sky is often a very important part to be studied. It requires, as a rule, very considerably less exposure than the foreground, hence the difficulty of obtaining natural skies and clouds in a negative. To do this, many methods have been recommended of giving a shorter exposure to this part of the picture; by stops having a graduated aperture or by shading a portion of the lens or the plate during exposure. The usual method, however, is to make cloud negatives and print them in the positive picture afterwards. See **Cloud Printing.** Recently several so-called ray-filters have been put on the market. These lesson the action of the blue rays, but unless used with judgment give an unnatural appearance to the picture.

SKY DIAPHRAGM.—See **Diaphragm.**

SKYLIGHT.—See **Studio.**

SKY NEGATIVES.—See **Cloud Negatives.**

SKY SHADE.—A shade or hood fitted over the lens to prevent the bright light from the sky from shining into the lens during exposure.

SLIDE CARRIER.—See **Plate Carrier.**

SLIDE, DARK.—See **Dark Slide.**

SLIDE LANTERN.—See **Transparency.**

SLIDING LEGS.—An arrangement in the camera tripod by means of which the legs can be shortened or lengthened at will. It is very useful when photographing in hilly and rocky country.

SNOW CRYSTALS, PHOTOGRAPHING.—Snow crystals evaporate rapidly even in low temperature, and the work requires to be done rapidly and with caution. Freshly fallen snow

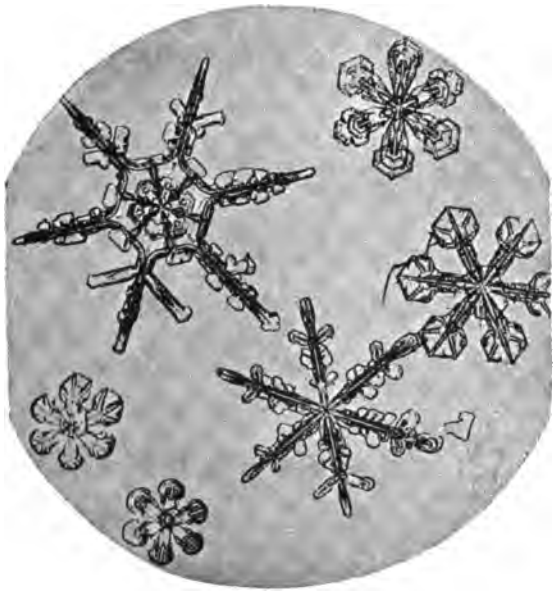


FIG. 413.—SNOW CRYSTALS.

Photo by Dr. Neuhaus.

FIG. 414.—SNOW CRYSTALS.

only will give a good photograph, and as we are compelled to work in the midst of the snow storm, the task becomes still more complicated and difficult. Snow crystals but a short time after falling break, the broken pieces freeze together and crystallization is destroyed. For the illumination of snow crystals, transmitted light only can be used, reflected light destroys the shadows, and injures the high lights, and the result is necessarily but a very imperfect picture of the object.

Diffused light, especially that of a dark winter's day, and during a snow storm, is not fit for this kind of photo-micrographic work, and we must resort to artificial light, preferably to that of a petroleum lamp. To prevent heat action emanating from the illuminating ray cone, an absorptive cell of alum solution should be interposed. As alum solution freezes solid in —5 deg. R., chloride of sodium is added. With Hartnark's projection system = 31 mm. focus distance, from 5 to 7 seconds upon an erythrosine plate is ample.

Dr. Neuhaus has made photographs of more than 60 different ice and snow specimens. The pictures of ice crystals much resemble those of hoar frost, deposited after a cold winter's night. Of snow crystals, the doublets are highly interesting, two crystals merged into one, and those having passed through a moist stratum of air, when microscopic drops of water will freeze into the hexagonal form, giving the picture an appearance very much resembling cauliflower.

SNOW PHOTOGRAPHY.—The photographing of snow scenes with natural and brilliant contrasts of black and white is not by any means an easy task. Many authorities have stated that snow scenes require sunlight, otherwise the result will be flat. Captain Abney, however, in photographing in the Alps, found that the color values of the landscape are often more correctly rendered as the light declines. His method is to expose four or five times longer than is usually done, so that there is a reserve of power, as it were, during the actual process of development, which is as follows:

(*a.*) Give plenty of alkali with very little pyro, and you get a feeble image; then increase the pyro, and you get density.

(*b.*) Add plenty of bromide, three or four times more than is ordinarily recommended, more particularly when there has been a very full exposure.

FORMULA.

Ammonia ten per cent. solution	40 minims
Potassium bromide	5 grains
Sodium sulphite sat. sol	60 minims
Pyro sufficient to cover the point of a small penknife.	
Water	2 ounces

(*c*) The image appears very, very gradually; indeed, before all the detail is apparent, a quarter of an hour elapses. When viewed by transmitted light the image will be a phantom one, and, if fixed, would be unprintable.

(*d.*) The next operation just reverses these principles; the developer is poured off, and pyro (this time a good quantity) and a little bromide are added to two ounces of water, and the necessary density is rapidly obtained, occasionally adding two or three drops of a ten per cent. solution of ammonia.

SOAP.—Combinations of the alkalies, potash and soda, with fatty acids, are what are usually termed soaps.

The soaps used in photography are—Castile soap (*q.v.*), used as a lubricator in burnishing; cyanogen soap, used for removing silver stains from the hands; and "Monkey" soap for cleaning glass or other materials.

SODA.—Common washing soda is an impure carbonate of soda (*q. v.*)

SODA, BICARBONATE OF.—See **Sodium Bicarbonate.**

SODA DEVELOPER.—See **Developer.**

SODAIC BLOTTING PAPER.—Sheets of blotting paper soaked in a 1 in 20 solution of sodium carbonate and dried. Sensitized paper, if laid between sheets of this paper and preserved from light and air, will keep for some time longer than if stored away in an ordinary manner.

SODIO-FERRIC OXALATE.—See **Ferric Sodium Oxalate.**

SODIO FERRIC OXALATE, HOW TO MAKE.—Prepare ferrous oxalate developer in the usual way, but in place of potassium oxalate take sodium oxalate. Pour the solution into a flat tray and allow it to evaporate spontaneously and in a perfectly dark room. A brownish, crumbly residue, interspersed with green crystals, will remain. Mix the residue with five times its weight of water, heat to less than boiling point, and dissolve carefully with a 15 per cent. solution of oxalic acid. Filter and evaporate to crystallization point. After setting aside for several hours, say over night, very beautiful emerald green crystals of sodio ferric oxalate will have formed on the bottom and sides of the vessels. Remove the crystals, wash off the mother liquids, dry between bibulous paper and keep them in the dark.

SODIUM ACETATE (Formula, $NaC_2H_3O_2$; molecular weight, 136).—A slightly alkaline salt, occurring in small transparent crystals. It can be prepared by neutralizing acetic acid with sodium carbonate. It is soluble both in water and alcohol. It is used in gold toning processes, and for this purpose should be free from chloride.

A hot, super-saturated solution of this salt will retain its heat for an exceptionally long time, and is for this reason used in foot-warmers for railway carriages.

SODIUM AURO-CHLORIDE (Formula, $NaCl{\cdot}AuCl_3{\cdot}2OH_2$).—An impure form of chloride of gold, often sold for photographic purposes.

SODIUM BIBORATE.—See **Borax.**

SODIUM BICARBONATE (Formula, $NaHCO_3$; molecular weight, 84; synonyms, *sesquicarbonate of soda, acid carbonate of soda, hydro-sodium carbonate*).—Prepared by passing carbonic acid gas into dampened sodium carbonate. It is soluble in water and insoluble in alcohol. It is used principally for toning. It takes the form of a white powder, and should not be confounded with the carbonate. To test a solution, add a few drops of a solution of perchloride of mercury. If a red precipitate is at once formed, it is a carbonate, and if a white, becoming red on boiling, it indicates a bicarbonate.

SODIUM BICHROMATE (Formula, $Na_2Cr_2O_7$; synonym, *sodium dichromate*).—Now very largely substituted for potassium dichromate (*q. v.*) On the Continent sodium bichromate is used for all the different photo-mechanical printing processes in place of the potassium salt. Its principal advantages over the latter are in the price and in its greater solubility, so that an

abundant addition may be made without fear of crystallization. It dissolves in double its quantity of water, potassium salt requiring as much as ten or twelve.

SODIUM BROMIDE (Formula, NaBr).—Occurs in small white crystals, obtained by saturating hydrobromic acid with soda. Soluble in water and alcohol. It is stated that its use in the preparation of gelatine emulsions causes them to become more sensitive to the orange and yellow rays than if either potassium or ammonium bromide be used.

SODIUM CARBONATE (Formula, Na_2CO_3).—Prepared by decomposing common salt with sulphuric acid, heating the resulting sulphate of sodium with chalk and small coal in a reverberating furnace, lixiviating the mass with cold or tepid water, evaporating the solution to dryness and calcining the product with sawdust in a suitable furnace. By dissolving the soda ash formed in hot water, filtering and allowing it to cool slowly, the carbonate is deposited in large transparent crystals, which effloresce in dry air and crumble to a white powder. When this is redissolved in water, filtered and the solution carefully crystallized, it constitutes the pure sodium carbonate used in pharmacy.

There are also a variety of impure forms of sodium-carbonate—common washing soda is one. It is, however, advisable in photographic operations to use the purest form. It is largely used for rendering solutions alkaline.

SODIUM CHLORIDE (Formula, NaCl; molecular weight, 57·5; synonyms, *chloride of sodium, common salt, salt, rock salt, etc.*)—Found abundantly in this country, principally in Cheshire, and in other countries. It also occurs dissolved in sea-water and in small quantities in most rivers, lakes and springs. It can be formed by the direct union of the elements.

Pure sodium chloride takes the form of minute white crystals, soluble in water, but insoluble in absolute alcohol.

It is sometimes employed in the salting of albumenized paper and in the manufacture of gelatino-chloride and collodio-chloride emulsions. It has also been recommended as an addition to the fixing bath to prevent reduction of the half tones.

SODIUM CITRATE.—There are three compounds of sodium and citric acid. Of these only one is used in photography. This is the normal citrate $C_6H_5O_7K_3 + H_2O$, which takes the form of deliquescent needles. It is used as a restrainer. To prepare, neutralize a solution of citric acid with sodium carbonate, and evaporate to dryness at 212 deg. Fahr.

SODIUM DICHROMATE.—See **Sodium Bichromate.**

SODIUM HYDRATE (Formula, NaOH; synonym, *caustic soda*).—Prepare similarly to the potassium hydroxide. Employed in alkaline development.

SODIUM HYPOSULPHITE (Formula, $Na_2S_2O_3 + 5H_2O$; molecular weight, 248; synonyms, *sodium thiosulphate, hyposulphite of soda, hypo*).—Formed by passing sulphurous acid gas through sodium sulphide until sulphur ceases to precipitate, or by heating sodium sulphite with excess of sulphur. It takes the form of irregular crystaline masses more or less transparent. If quite pure it should not effloresce.

Sodium hyposulphite is very soluble in water and insoluble in alcohol. It does not keep very well when in the form of solution. Its keeping properties are, however, improved by the addition of sodium carbonate till alkaline. The addition of salicylic acid has also been recommended for this purpose. It should also be noted that solutions of this salt keep better in the dark than in the light.

Commercial sodium hyposulphite should be tested for sodium sulphate, which is often contained in it. Leaper's instructions are to mix an aqueous solution of it with an excess of hydrochloric acid free from chlorine, filtered off the precipated sulphur, and adding barium nitrate to the filtrate, when a white precipitate will occur, if sodium sulphate is present.

Hyposulphite of soda was first prepared by Chaussier, as far back as 1799. In 1869 Schutzenberger showed that the so-called "hyposulphurous acid" was really thiosulphuric acid,* from which it resulted that the salts, previously termed hyposulphites, were in reality, *thiosulphates*.† The correct name for this substance is therefore sodium thiosulphate, although the familiar name of hypo will not be easily or soon discarded.

The principal use of hyposulphite of soda in photography is as a fixing agent owing to the fact of its being a solvent of the silver haloids. This property was first discovered by Sir William Herschel about the year 1819. If a silver salt be added to sodium hyposulphite two salts are formed, thus, for instance, with silver chloride in silver printing—

$$AgCl + Na_2S_2O_3 = AgNaS_2O_3 + NaCl$$
$$2AgCl + 3Na_2S_2O_3 = Ag_2Na_4(S_2O_3)_3 + 2NaCl$$

*"Comptes Rendus," vol. lxix., p. 196. †Harrison's "History of Photography."

The first salt $AgNaS_2O_3$ is a double hyposulphite of silver and sodium, which is with difficulty soluble in water, but soluble in sodium hyposulphite. It is for this reason that it is important to use an excess of sodium hyposulphite, so as to completely eliminate the insoluble salt, as upon this rests, to a considerable extent, the permanency of the image. Many substances have been recommended to get rid of the excess of sodium salt (see **Eliminator, Hypo,**), but these, as a rule, are as injurious as the hypo itself. After thoroughly well washing the prints in many changes of water, a test for hypo should be used. This is usually made up as follows:

Potassium permanganate	1 grain
Potassium	10 grains
Distilled water	20 ounces

This will form a pinkish purple liquid, and a few drops are added to the last washing water. If hypo be present a slightly greenish color will appear. The prints should be made to receive a further washing, and the test again applied. Another method is to make a little starch paste by boiling a little starch in distilled water, and adding thereto a few drops of an alcoholic solution of iodine. A deep blue color will be formed, due to the formation of iodide of starch. One or two drops of this deep blue liquid are added to the last washing water, and if hypo is present the blue color will disappear. Mercuric chloride is also used as a test for hypo. A few drops of a solution of it added to the washing water will cause a cloudiness if any hypo be present. A very minute quality of a dilute hyposulphite solution added to the ferrous oxalate developer has a very powerful accelerating action. Hypo solution is also an excellent cleanser of silver articles.

If an acid be added to a solution of sodium hyposulphite, sulphurous acid will be evolved and sulphur deposited. It is for this reason that the fixing bath for printing should be made distinctly alkaline.

The photographer who desires good and permanent results should at all times attend to the purity of the chemicals he is using, and with his hypo no less than with the others. The two principal impurities to be found in hyposulphite are sodium chloride and sodium sulphate, two substances that are cheaper than hypo, and consequently often added for the sake of extra profit to the manufacturer. Every suspected sample of hypo should be tested for sodium sulphate, the principal and most undesirable adulteration. This may be roughly done by exposing a few lumps to the air in a warm place for a week or so, when the presence of any considerable quantity will be apparent from an increased dryness, and by the efflorescence of the sulphate due to the discharge of the water of crystallization.

If a more rapid means of testing is desired, Leaper's instructions may be followed. These are to mix an aqueous solution of the hyposulphite to be tested with an excess of hydrochloric acid, free from chlorine, filtering off the precipitated sulphur and adding barium nitrate to the filtrate, when a white precipitate will occur if sodium sulphate is present.

The *British Journal of Photography* says: "Should any one desire to ascertain with exactitude whether any sample is pure, it can easily be done by a solution of pure dry iodine; 24·8 grains of clean dry hypo ought to be entirely decomposed by 12·7 grains of iodine; any defect in the quantity of the latter required to effect complete decolorization of its solution indicates the proportion of impurity present."

Sodium hyposulphite is very soluble in water, but insoluble in alcohol. It is a common belief that an aqueous solution will keep indefinitely, and in many photographic establishments large quantities are made up to last for some time, no precautions being taken to prevent decomposition. This is a great mistake. Watts, in his Dictionary of Chemistry, states that "an aqueous solution cannot be preserved unaltered even in closed vessels, but deposits sulphur, and is partly converted into sodium sulphate; in contact with the air it is gradually but completely oxidized into sulphate." It is evident, therefore, that in making up large quantities of hypo solution for fixing purposes and using when required, the photographer runs no inconsiderable risk of destroying the permanency of his prints.

Decomposition can, however, be prevented to a very great extent, although not totally, by the addition of sesquicarbonate of ammonia (Mohr) until alkaline. Caustic soda has been recommended for this purpose, and also salicylic acid. Another point that should be observed is that solutions of hyposulphite of soda will keep better in the dark than when exposed to light.

SODIUM NITRATE (Formula, $NaNO_3$; molecular weight, 85. Synonym, *nitrate of soda.*) Occurs native in Chili, and sometimes termed "Chili saltpetre." It takes the form of deliquescent crystals, soluble in water and alcohol. It is sometimes added to the silver bath for albumenized paper, as it tends to keep the image on the surface of the paper. It is also recommended as an addition to developers to obtain a good chocolate color.

SODIUM OXALATE (Formula, $Na_2C_2O_4$; synonym, *oxalate of soda*).—Takes the form of fine lustrous needles: is soluble in twice its weight of boiling, and 35 times its weight of cold water. It is used in the printing-out platinotype process.

SODIUM PHOSPHATE (Formula, HNa_2PO_4+; 12 HO_2; molecular weight, 358; synonym, *hydrodisodium phosphate*).—Prepared by neutralizing phosphoric acid with an alkaline salt of soda. It is soluble in water, but insoluble in alcohol. It takes the form of prismatic crystals, which effloresce in air. It is used in the toning process.

SODIUM PYROBORATE.—Synonymous with **Borax** (*q. v.*).

SODIUM SALTS.—Tests for solutions containing sodium give a white precipitate with potassium antimoniate.

SODIUM SILICATE (Synonyms, *water glass, soluble glass*).—A combination of soda with silica. It is usually prepared by fusing 15 parts of fine sand with eight parts of sodium carbonate and one part of powdered charcoal. It occurs in white masses, but little affected by cold water, but readily soluble in boiling water, yielding a strong alkaline liquid.

It is employed in the collotype and in other processes mixed with albumen to form a substratum for glass plates required to be coated with collodion.

SODIUM SULPHANTIMONIATE (Formula $NaSbS_3$; synonyms Schleppe's salt).—Occurs in transparent deliquescent crystals freely soluble in water. It is sometimes employed in intensifying collodion.

SODIUM SULPHATE (Formula Na_2SO_4 10A_2O; molecular weight 322; synonym, *Glauber's Salt*).—Sodium sulphate has been recommended as a substitute for sodium sulphite in the developer. Herr Peppel gives the following method of development. For a properly exposed plate it is immersed for a few seconds in a bath of

Pyro	1 gr.
Sat. sol. sodium sulphate	20 to 40 c. c.
Water	100 c. c.

to which being returned to the developing measure is added 2 to 10 c. c. of a saturated solution of sodium carbonate, development being then resumed with the mixed solution.

SODIUM SULPHITE (Formula, Na_2SO_3; molecular weight, 126; synonym, *sulphite of soda*).—Prepared by passing sulphur dioxide over damp crystals of sodium carbonate, the following representing the change that takes place.

$$CO_2 + SO_2 = Na_2SO_3 + CO_2.$$

It takes the form of prismatic crystals, soluble in four times its weight of cold and twice its weight of hot water.

Much difficulty has been experienced in getting pure sodium sulphite as necessary for photographic purposes, but recently, however, manufacturers have discovered the necessity of putting this on the market, and it is now easily obtainable.

The crystals should be quite transparent and free from a powdery appearance on the outside. They should not smell of sulphur dioxide, denoting the absence of sodium bisulphite. To test samples of sodium sulphite dissolve 10 grains in a drachm of strong hydrochloric acid, free from chlorine, and dilute with half an ounce of water; add to this a few drops of a solution of barium nitrate. Only a very slight precipitate should be formed. If this is considerable, however, it denotes the presence of large quantities of sodium sulphate. Mr. J. C. Belcher, on referring to the purity of sulphites for photographic purposes, says: "The presence of an excess of sodium carbonate in the sulphite causes great annoyance to photographers, as by its varying amount, they are unable to make any allowance in their formula, which demands an addition of a definite amount of the former in conjunction with the latter for developing. The presence of carbonate in sulphite of sodium is easily detected. The method depends upon the fact that carbonic acid gives a beautiful red color with an alcoholic solution of phenolphthaleïn, while sulphurous acid produces no action in this respect.

"If, then, we dissolve some of the sulphite above referred to containing only one or two per cent. of carbonate, add a little alcoholic phenolphthaleïn, we shall have a red color developed, due to the carbonic acid, and on adding carefully a solution of the meta-sulphite—preferably potassium meta-sulphite, as this crystallizes much more freely than the sodium salt, and is more stable—till the color just disappears, the result is a pure solution of neutral or normal sodium (potassium) sulphite, the SO_2 radical combining with the sodium which was previously combined with the CO_2 radical. The question, therefore, of obtaining a pure solution of normal or neutral sulphite of sodium need no longer perplex photographers.

The same writer refers to the fact that sulphites oxidize more or less rapidly than sulphates,

and suggests as a means of preserving that they should be kept in well stoppered bottles, with the crystals covered with pure ether. When required for use they could be laid for a few seconds on blotting paper to dry, preparatory to dissolving.

Its use in photography is principally as a so-called preservative of pyro, as it absorbs oxygen, and is converted into sulphate, preventing the pyro from becoming discolored.

It is also used in mercurial intensification.

In 1885 Captain Abney pointed out that sodium sulphite is an excellent fixing agent. It is, however, considerably more expensive than hypo. It is used in the proportion of about four ounces to the pint of water. Sodium sulphite has also been recommended as an addition to the hyposulphite bath, to prevent it from discoloring negatives after it has been used for some time. See PHOTOGRAPHIC TIMES, page 306, Vol. XXIV.

SODIUM THIOSULPHATE.—See **Sodium Hyposulphite.**

SODIUM TUNGSTATE (Formula, $Na_2WO_4 + 2H_2O$; synonym *tungstate of soda*, molecular weight, 317).—Prepared by fusing wolfram with sodium carbonate. It crystallizes in rhomboidal plates soluble in water, but insoluble in alcohol. It is principally employed in the toning process.

SOFT EFFECTS.—The question whether a photograph should be sharp all over or not still remains an undecided one among photographers. Many point out that the eye can only see objects on one plane, sharp. If farther away, they appear blurred until the eye focuses itself upon them, when the objects which were sharply defined on the retina beforehand become diffused. On the other hand, scientists like Captain Abney and others declare that unsharp images are unnatural.

It is not our intention here to attempt to decide the question. While for many purposes we like to see a well-defined image, yet we cannot help admitting that soft, diffused images have won our admiration, and it is our purpose to give some of the methods employed in their manufacture.

First of all, however, it must not be imagined that any picture made unsharp will be a success. Nothing is more ridiculous to see than some of the attempts at diffused images made by some photographers imitating the "naturalistic" or "impressionist" school.

The artist gives a soft effect to a picture where he thinks it necessary to convey the impression he desires. The photographer can do the same, but he must know what he is doing, and the picture itself must be his chief guide.

Diffused images are not new by any means. Many years ago Dallmeyer constructed a doublet lens so arranged that, after focusing, the back and front combinations could be slightly separated to give a diffused effect. These were largely employed in portraiture, but the general public preferred a sharp image, where every hair of the head was plainly visible.

A diffused image can be obtained by altering the focus during the exposure, but this method is rarely satisfactory, and the results are quite different from those which give the most pleasing effect.

Vibrating the camera during the exposure was another curious method that was recommended. A cord was tied from the center of the camera tripod head to a heavy weight on the ground. As soon as the lens was uncapped a violin bow was drawn across the cord and a vibration of the whole was set up, giving a peculiar diffused effect to the image.

The interposition of a sheet of transparent celluloid or a thin plate of glass between the negative and the printing paper is the manner in which some operators obtain their diffused effects. Sometimes printing is carried half way in the ordinary manner, the glass inserted and the picture printed out. This gives a peculiar soft effect, while the image still appears sharp.

There are various other methods of diffusing the image, many of which will readily suggest themselves to the reader. For instance, by holding a spirit lamp beneath the lens during the exposure, a rarefaction of the air takes place and the image is thrown out of focus, as often seen on a hot day when the heat rays are ascending from the stone walks.

If an exposure be made partly with a small diaphragm and partly with the full aperture a peculiar soft effect can often be produced. A picture is obtained which gives the appearance of being neither sharp nor blurred. The small stop, of course, gives a sharp image during half the exposure and the full aperture an unsharp one owing to the spherical aberration. Mr. Charles Whiting, in the last number of the "British Journal Almanac," gives another method somewhat similar to this. The following is what he says: "I find I can produce any degree of softness or blurring desired, and the means are simple. It is to use in the place of the ordinary diaphragm others made of cardboard with the apertures ranging from *f*/8 to *f*/16, or thereabouts, and on these are glued rather thick collodion films with apertures equivalent to about *f*/30. I also find the thickness of the collodion film a most important factor in giving to the diaphragm its fuzzy-producing qualities. If I wish to give only a soft, pleasing effect to the picture I use a diaphragm with an opening on the cardboard of *f*/16, together with an opening in the collodion film of *f*/30, and if I wish for more fuzziness I increase the area of the disturbing element (the collodion film) by enlarging the hole in the cardboard to, say, *f*/12, or *f*/8, and keeping the hole in the

collodion film the same or making it smaller. If I wish to carry the effect to an extreme limit I use a thicker film of collodion, or two films combined, on the same diaphragm, and it may also be done by using one film, but without any hole at all."

A method recently adopted is to interpose between the negative and printing paper a piece of bolting cloth, a kind of muslin, which can be obtained with varying degrees of fineness.

SOLAR CAMERA.—See under **Camera.**

SOLAR ENLARGING.—See **Enlarging.**

SOLARIZATION.—A peculiar effect produced by long exposure of a photographic sensitive film to the action of light resulting in the complete reversal of the image from a negative to a positive. It is also noticeable when photographing objects of intense brightness. Fig. 415 shows the reversal of the image of an electic arc.

The phenomenon of solarization has been found to be of a recurrent character. Thus if a dry plate be exposed for a certain length of time a negative is obtained on development, this being the ordinary process of photography. If the exposure be considerably increased the plate on development will be quite dark all over, showing no signs of the image. This is termed the first neutral stage. By still further prolonging the exposure the reversal of the image takes place, and a positive is obtained instead of the negative. This reversal is followed by a second neutral stage, and this is in turn succeeded by an ordinary negative as would have been first obtained, and the phenomena succeed each other again in the same order as before by continued exposure to a strong light. It has been estimated that the second negative stage requires for its production a light of 100,000 times the intensity of that required for the formation of the first negative image.*

FIG. 415.—PHOTOGRAPH SHOWING REVERSAL OF THE IMAGE OF AN ELECTRIC ARC.

No very satisfactory explanation has ever been given of this peculiar phenomenon. It has, however, been discovered that a preliminary exposure to white light facilitates the reversal. Further, a strong developer acts in the same manner as over-exposure, so that a solarized plate might give a negative with a weak developer, and a positive image with a strong one. Abney discovered that oxidizing agents facilitate reversal, while reducing agents either retard it or prevent it altogether.

The effect of solarization and reversal of the image is perfectly invisible until development.

In the old wet-collodion days, when silver iodide was used, this phenomenon was often met with; for instance, in a landscape negative, when other parts of the image were correctly exposed, the sky would appear nearly as a blank, any small deposit of silver having a red hue; later on, when bromide was added to the collodion, this occurrence was rare, but with gelatine dry plates it often makes its appearance.

Jannsen, in Eder's "Jahrbuch," 1894, has stated that the phenomenon of solarization runs through several phases, namely:

1. The ordinary negative.
2. The negative darkens all over after longer exposure (first neutral condition).
3. The positive image.
4. Second neutral condition.
5. Second negative requiring an exposure of 100,000 times longer than that of the first order.
6. Third neutral condition.

According to the brothers A. and L. Lumière, the first neutral condition represents distinctly the maximum of density, to be attained by developing a bromide of silver gelatine plate after exposure.

The reversal of the first negative into a corresponding positive requires an exposure 360,000 times longer than an ordinary negative.

Jannsen's second neutral condition the Lumières have never obtained, although the exposure was 480,000 times longer than for an ordinary negative.

Gravier gives a general synopsis on these and similar experiments.

F. Kogelman (*Photo Corres.*, 1892) says the reversal of the image is effected by three causes.

* Meldola.

1. A plate exposed 18,000 times longer than normally produces a positive but not a negative picture; or

2. When a normally exposed plate is subjected to the action of light under development.

3. When a normally exposed plate is developed with certain substances to which other substances are added, for example, hyposulphite of sodium to ferrous oxalate, or thiocarbonides to eikonogen.

He says further on, metol, with much alkali, develops positives upon normally exposed plates, but the image is of a dualistic character. On top of the film rests an extremely thin negative, and beneath it is a positive which, under the circumstances, cannot possess clear whites. The reduced silver of the negative is of gray color, the positive is yellowish-gray by reflected light, and violet by transmitted. The positive character prevails invariably with such plates, but in no case total absence of the negative has been reported.

Amidol with much ammonia develops positives on a normally exposed plate, also of androgyanous character.

Von Norath publishes an article on solarization in *Deutsche Photographen Zeitung*, and after his investigation of the silver bromide comes to the conclusion solarization is the result of oxidation in light.

But in his hypothesis he goes much further than Eder and Abney, and he asserts the solarized picture consists of bromate of silver, $AgBrO_3$.

In an answer to von Norath, Eder showed how much he misconceives the fundamental ideas about bromate and bromide of silver, which in fact are both identical.

Solarization phenomena occur with Abney only when oxygen is present, never in its absence (in an atmosphere of hydrogen, or under the influence of reducing agents), which shows the solarized image need not necessarily consist of bromate of silver, for the same phenomena takes place with bromide of silver. Bromate of silver will be decomposed by bromide; in fact it cannot exist in its presence.

SOLAR SPECTRUM.—See **Spectrum.**

SOLIDIFICATION.—The passage of bodies from the liquid to the solid state, or the reverse of fusion. It is accompanied by evolution of heat and in general by change in volume. Two principal laws govern the phenomenon. These are:—

(1.) Each substance solidifies at a fixed temperature if the pressure upon it be always the same; that temperature is the temperature of fusion for the body.*

(2.) From the commencement to the close of the process the temperature of the liquid remains at a fixed point.

SOLUBLE GLASS.—An impure alkaline silicate, prepared by fusing for five or six hours a mixture of quartz, sodium and potassium carbonate and powdered charcoal, pulverizing the fused mass, boiling with water for three or four hours, and concentrating the solution to a sp. gr. of 1.24. It is used as a varnish and in the collotype process.

SOLUTION.—A term applied to the product of the action, as well as to the action itself, whereby a solid or gaseous body in contact with a liquid suffers liquefaction, or to the union of one liquid with another when each is capable of taking up only a limited quantity of the other. When a liquid adheres to a solid with sufficient force to overcome its cohesion, the solid is said to undergo solution or become dissolved. By diminishing cohesion in the solid, as by reducing it to powder, solution is facilitated, in consequence of the larger extent of surface exposed to the action of the solvent. Heat also, by diminishing cohesion, favors solution. In adding the solid to the liquid, the first portions will usually disappear rather quickly, but as more is added solution proceeds slower and slower, until it ceases altogether. The solution is then said to be saturated. The solution of a solid in a liquid is usually attended with a fall in the temperature, excepting where solution is preceded by the formation of a definite chemical compound. The solution of one liquid with another occurs without change of temperature, excepting in cases in which chemical union takes place, as in the dilution of sulphuric acid with water. It does not always happen that heat increases the solvent process of a liquid. Lime, for instance, is more soluble in cold water than in hot.

Various solids dissolve in the same liquid at very different rates and in different proportions. The following will be found a fairly complete list of the solubilities of the chemicals used in photographic operations:—

* Under certain conditions this law can be departed from; water enclosed in fine capillary tubes has been lowered to a temperature of —20°C before solidifying.

TABLE OF SOLUBILITIES OF THE VARIOUS CHEMICALS USED IN PHOTOGRAPHY.

(From the American Annual of Photography)

s. soluble; v.s., very soluble; sp. s., sparingly soluble; n.s., not soluble: dec., decomposed.

Name.	One part is soluble in cold water.	One part is soluble in hot water.	Alcohol.
Alum, potash	10	8	n.s.
Alum, chrome	10	dec.	n.s.
Ammonia, gaseous	v.s.		
Ammonium bichromate	v.s.	v.s.	
Ammonium bromide	1·5	1	1 in 13
Ammonium carbonate	4	dec.	sp. s.
Ammonium chloride	3	1	sp. s.
Ammonium fluoride	v.s.	v.s.	sp s.
Ammonium iodide	1	·5	s.
Ammonium nitrate	2	1	s.
Ammonium oxalate	v.s.	v.s.	1 in 2
Ammonium sulphide	v.s.	v.s.	1 in 2
Ammonium sulpho-cyanide	1	·5	s.
Barium bromide	·96	·75	s.
Barium chloride	2·18	1·5	sp. s.
Barium iodide	·48	·35	v.s.
Barium nitrate	12	3	sp. s.
Barium peroxide	n.s.	n.s.	in hydrochloric acid.
Boracic acid	30	3	1 in 30
Borax	12·5	2	n.s.
Cadmium bromide	1·5	1	sp. s.
Cadmium chloride	·71	·67	sp.s.
Cadmium iodide	1·5	1	1 in 2
Calcium bromide	1	·75	s.
Calcium carbonate	n.s.	n.s.	n.s.
Calcium chloride	·75	·5	1 in 10
Calcium hypochlorite	sp. s.	sp. s.	dec.
Calcium iodide	·75	·5	1 in 10.
Carbolic acid	16·6	s.	s.
Citric acid	·75	5	10 in 15
Cobalt chloride	1	·75	s.
Copper acetate	14	·5	1 in 14
Copper bromide	1	·75	s.
Copper chloride	1	·75	v s.
Copper nitrate	3	1	s.
Copper sulphate	3	1	n.s.
Gallic acid	100	3	1 in 8
Glycerine	s.	s.	s.
Gold perchloride	1	·75	s. and in ether.
Hydroquinone	3	s.	s. and in ether.
Hydroxylamine	v.s.	v.s.	n.s.
Iron ammonium sulphate	v.s.	dec.	s.
Iron chloride (ferric)	·75	·5	1 in 1
Iron chloride (ferrous)	2	1	1 in 1
Iron citrate	s.	s.	n.s.
Iron iodide	v.s.	v.s.	v.s.
Iron nitrate	v.s.	dec.	dec.
Iron oxalate (ferric)	s.	s.	n.s.
Iron oxalate (ferrous)	s.	in excess of alkaline oxalate only.	
Iron sulphate (ferric)	s.	dec.	s.
Iron sulphate (ferrous)	1·5	1	n.s.
Lead acetate	2 5	2	1 in 12 5
Lead carbonate	n.s.	sp. s.	n.s.
Lead iodide	s.	s.	n.s.
Lead nitrate	7·7	7	s.
Lead oxide	n.s.	n.s.	alkalis.
Lithium bromide	·66	·5	v.s.
Lithium chloride	1·3	1	s.
Lithium iodide	·61	·5	s.
Magnesium bromide	1	75	s.
Magnesium chloride	2	1·5	s.
Magnesium iodide	1	.75	v.s.
Magnesium sulphate	1·3	1	sp. s.
Mercuric chloride	19	3	5
Mercuric iodide	sp. s.	sp. s.	sp. s.
Mercurous chloride	n.s.	n.s.	n.s.
Mercurous iodide	n.s.	n.s.	n.s.
Mercury cyanide	8	2	1 in 20
Oxalic acid	8	1	n.s.

s., soluble; v.s., very soluble; sp.s., sparingly soluble; n.s., not soluble dec., decomposed.

Name.	One part is soluble in cold water.	One part is soluble in hot water.	Alcohol.
Platinum chloride	1	·5	s.
Potassium bicarbonate	3	2	n.s.
Potassium bichromate	10	7	n.s.
Potassium bromide	2	1	1 in 90
Potassium carbonate	·75	·5	n.s.
Potassium chlorate	16	2	n.s.
Potassium chlride	3	2	sp. s.
Potassium citrate	·6	3	n.s.
Potassium cyanide	·1	·5	sp s.
Potassium ferric sulphate	s.	s.	s.
Potassium ferricyanide	2·5	1.2	n.s.
Potassium ferrocyanide	3	1	n.s.
Potassium fluoride	v.s.	v.s.	v.s.
Potassium hydrate	·5	·25	sp. s.
Potassium iodide	·75	·5	1 in 16
Potassium nitrate	4	1	n.s.
Potassium oxalate	3	2	sp. s.
Potassium permanganate	16	10	n.s.
Potassium platino-chloride	10	1	s.
Potassium sulpho-cyanide	2	1	sp.s
Pyrogallic acid	3·5	1	v.s. and in ether.
Salicylic acid	760	9	v.s. and in ether.
Silver acetate	sp. s.	sp. s.	n.s.
Silver bromide	n.s.	n.s.	in H Cl & H Br
Silver carbonate	n.s.	n.s.	n.s.
Silver chloride	n.s.	n.s.	s. in am. pot. cy'de & hypo
Silver citrate	sp. s.	sp. s.	
Silver fluoride	v.s.	v.s.	v.s.
Silver iodide	n.s.	n.s.	s. in am. pot. cy'de & hypo
Silver nitrate	1	·5	sp. s.
Silver nitrite	300	dec.	n.s.
Silver oxalate	sp. s.	s.	n.s.
Silver oxide	n.s.	n.s.	n.s.
Silver sulphate	200	88	n.s.
Silver sulphite	n.s.	n.s.	n.s.
Sodium acetate	3	66	n.s.
Sodium biborate	12·5	2	n.s.
Sodium bromide	1·25	1	1·16
Sodium bicarbonate	12	dec.	n.s.
Sodium carbonate	2	1	n.s.
Sodium chloride	2·75	2·75	n.s.
Sodium citrate	1	·5	sp. s.
Sodium hydrate	1·5	·5	sp. s.
Sodium hyposulphite	1·5	1	sp. s.
Sodium iodide	·5	·3	sp. s.
Sodium nitrate	1·36	1	1 in 7
Sodium phosphate	4	2	n.s.
Sodium sulphate	2	·4	s.
Sodium sulphide	s.	s.	sp. s.
Sodium sulphite	4	2	sp. s.
Sodium tartrate	1·75	1	n.s.
Sodium tungstate	4	2	n.s.
Strontium bromide	1	·75	sp. s.
Strontium chloride	1 8	1	sp. s.
Strontium iodide	·5	·25	s.
Strontium nitrate	5	2	sp. s.
Tannic acid	·8	·5	10 in 8
Tartaric acid	·8	·5	1 in 5
Tin chloride (stannic)	dec.	sp. s.	
Tin chloride (stannous)	v.s.	v.s.	v.s.
Uranium bromide	1	·5	sp s.
Uranium nitrate	·5	·25	v.s.
Uranium oxalate	sp. s.	30	n.s.
Uranium sulphate	·5	·25	v.s.
Zinc bromide	1	·5	s.
Zinc chloride	·33		s.
Zinc iodide	·33	dec.	v.s.
Zinc sulphate	7	5	n.s.

SOLUBLE GLASS.—See **Sodium Silicate.**

SPATULA.—A little instrument used for mixing up chemical compounds in the form of paste. See Fig. 416.

FIG. 416.—SPATULA.

SPECIFIC GRAVITY.—The relative weight or gravity of any body or substance, considered with regard to an equal bulk of some other body, which is assumed as a standard of comparison. The standard for the specific gravities of solids and liquids is pure distilled water, at a temperature of 62 deg. Fahr., which is reckoned unity. By comparing the weights of equal bulks of other bodies with this standard, we obtain their specific gravities. Thus the specific gravity of cast-iron is 7.21, that is, any particular mass of cast-iron will weigh 7.21 times as much as an equal bulk of water. The practical rule is, weigh the body in air, then in pure distilled water, and the weight in air, divided by the loss of weight in water, will give the specific gravity of the body. In designating the gravities of gases, the standard of unity is atmospheric air.* In order to calculate the amount of water to be added to a liquid to reduce it to a lower specific gravity, subtract the specific gravity of water from the required specific gravity, and the result will be the amount of liquid to be taken. The difference between the specific gravity of the liquid and the required specific gravity represents the amount of water. For example, suppose we have a sample of sulphuric acid having a specific gravity of 1.845, and it is required to use an acid with a specific gravity of 1.3, how much water must be added to the strong acid to obtain the weak? 1.845—1=.845=the amount of strong acid; 1.845—1.3=.545=the amount of water.

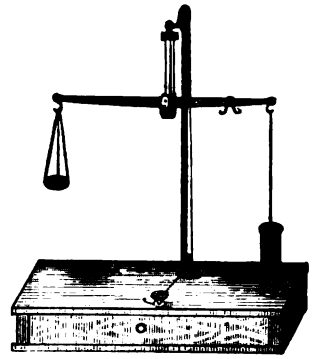


FIG. 417.—SPECIFIC GRAVITY BALANCE.

Thus, if we add 545 parts of water to 845 parts of strong sulphuric acid, we shall obtain an acid having a specific gravity of 1.3, or if we add 1 ounce 65 minims (fluid measure) of water to 1 ounce 6 drachms and 5 minims of strong sulphuric acid, we shall obtain about 23 drachms of sulphuric acid having a specific gravity of 1.3.

SPECIFIC HEAT.—A term applied to the quantity of heat required to raise equal weights of different substances through equal intervals of temperature. Water is taken as the standard substance in measuring quantities of heat.

SPECTROSCOPE.—An instrument employed in spectrum analysis. It usually consists of the following parts: (1.) A tube with a narrow slit at one end and a convex lens at the other, from which parallel rays of light proceed when light is made to pass through the slit, the two forming together what is termed the collimator. (2.) A prism of dense flint glass on which the rays fall after emerging from the collimator. (3.) An observing telescope so placed that the rays traverse it after emerging from the prism.

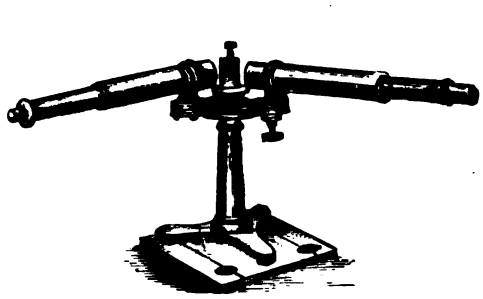


FIG. 418.—SPECTROSCOPE.

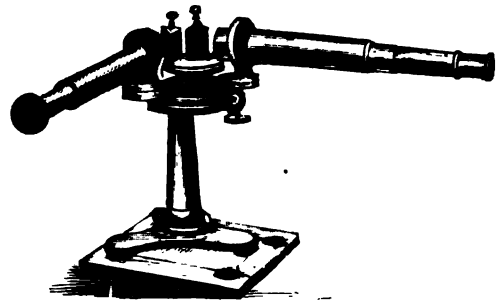


FIG. 419.—SPECTROSCOPE.

Fig. 423 gives a ground plan of the arrangement: S is the slit, C the collimating lens, P the prism, O the object glass of the telescope, and E the eye-piece. An image of the slit will

FIG. 420.

FIG. 421.

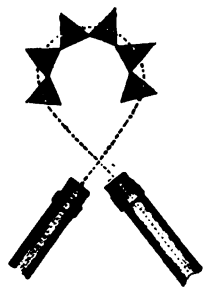


FIG. 422.

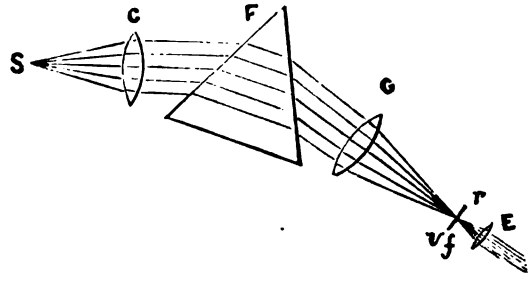


FIG. 423.

* Annandale's Cyclopædia.

be formed at *f* by rays of given refrangibility, others between *f* and *v* by rays of greater refrangibility, and others between *f* and *r* by rays of less refrangibility, thus giving a complete spectrum.

Burton in his "Photographic Optics" says: "Sometimes quite a number of prisms are used to gain greatly increased dispersion. An arrangement—the invention of the famous optician, Browning—for the use of six prisms, is shown in Fig. 422; the dotted line shows the direction taken by a ray of monochromatic light. Mention must on no account be omitted of the direct vision spectroscope, as this is a little instrument particularly useful to photographers.

By referring to what has been said in Chapter III* on the means of correcting chromatic aberration, and considering how we may *bend* a ray of light without *dispersing* it, it will readily be understood that, by a modification of the same arrangement, we may *disperse* a ray of light without *bending* it. By so doing, we may have a spectroscope with the collimating tube and the eye-piece in a straight line, in place of at an angle with each other. Only a limited amount of dispersion is, of course, permissible with this arrangement, or the spectrum would pass beyond the field of view.

The next two cuts, Figs. 420 and 421, show the arrangement of prisms for dispersing a beam of light without deflecting it. In each case the darker shaded prisms are of flint, the lighter of crown glass.

The chief use of the direct vision spectroscope to photographers is in examination of mediums for dark-room illumination. Most photographic work is done by light of short wave lengths—blue, violet, etc. Sensitive films are, therefore, most easily worked in light of long wave lengths – red, yellow, etc. Colors that appear to the eye quite simple are often in reality compound. Thus, there are two kinds of red glass, to the eye as like each other as can be, but one of which transmits only red light and, perhaps, a very little green, while the other transmits a considerable amount of blue or purple also. The latter, it will be evident, is quite unsuited to dark-room illumination. The two cannot, as has been said, be distinguished by the eye, but they can at once when the light passing through them is examined by the spectroscope.

The spectrum extends in both directions beyond what can be seen by the eye, the rays of greater and less refrangibility than those visible to the eye being termed ultra-violet and ultra-red rays. Photography has been particularly useful in mapping these.

There is the objection to the prism spectroscope that the glass of the prism absorbs—or *stops*—some of the invisible rays. Fortunately a spectrum can be obtained otherwise than by a prism. It can be got by the aid of a 'diffraction grating.' A diffraction grating is a polished surface—such as speculum metal—ruled with lines so close together that there are many thousands to the inch. This, on account of what is called *interference of light*, gives a very perfect spectrum, none of which is absorbed. The subject of the diffraction grating is rather too complex to treat of in detail here."

SPECTRUM.—The stripe formed on a screen by a beam of light, as of the sun, received through a narrow slit and passed through a prism, being thus decomposed or separated into its constituent rays. This oblong stripe consists of a number of colors shading imperceptibly into one another from red at one end, through orange, yellow, green, blue, indigo, to violet at the other. (See Fig. 424.) These colors are due to the different constituents of which solar light is made up, and the stripe seen is formed by an indefinite number of images of the slit ranged in order and partially over-lapping. The analysis or decomposition of the beam is due to the different refrangibilities of the component rays, the violet being the most refrangible and the red the least. Besides the visible color rays, the spectrum contains thermal or heating rays, and chemical or actinic rays, which are not visible to the eye. The heating effect of the solar spectrum increases in going from the violet to the red, and still continues to increase for a certain distance beyond the visible spectrum at the red end, while the chemical action is very faint in the red, strong in the blue and violet, and sensible to a considerable distance beyond the violet end. The actinic rays beyond the violet may be rendered visible by throwing them upon a surface treated with some fluorescent substance.†

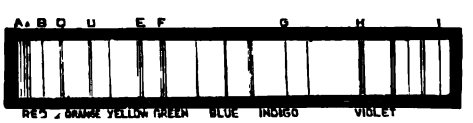


FIG. 424.

Besides this band of different colors, a pure solar spectrum will be found to possess a number of dark lines, which cut through it perpendicularly. These lines were first discovered by Wollaston, and were carefully studied by Frauenhofer and called after him Frauenhofer's lines. The lines are always to be found on the same spot, and serve to indicate the exact places on the scale of color. For instance, if we use the term blue in the spectrum, this is naturally vague and incomplete, but by indicating the line on the spectrum in which this color is found no difficulty will arise. For this purpose Frauenhofer gave certain characteristic names to the line, which he indicated by letters. A certain line in the red he called A, another in the yellow D, and so on. As, however, these lines number some thousands it is evident that these letters will not suffice to indicate them all. Fig. 424 shows the position of the

* See Aberration. † Blackie's "Modern Cyclopædia."

most conspicuous of these fixed lines, and the letters above them are the names by which they are known.

In order to properly understand these lines it is necessary to remember five important things. These are: *Firstly*, an incandescent solid or liquid body gives out a *continuous* spectrum; *secondly*, an incandescent gaseous body gives out a *discontinuous* spectrum consisting of bright lines; *thirdly*, each element, when in the state of an incandescent gas, gives out lines peculiar to itself; *fourthly*, if the light of an incandescent solid or liquid passes through a gaseous body, certain of its rays are absorbed, and black lines in the spectrum indicate the nature of the substance which absorbed the ray; *fifthly*, each element, when gaseous and incandescent, emits bright rays identical in color and position on the spectrum with those which it absorbs from light transmitted through it. The spectrum of sodium, for instance, shows two bright lines which correspond in position with the double black line at D (the sodium line). Now, applying these principles to the solar spectrum, we find, from the nature and position of the rays absorbed that its light passes through hydrogen, potassium, sodium, calcium, barium, magnesium, zinc, iron, chromium, cobalt, nickel, copper, and manganese, all in a state of gas, and constituting part of the solar envelope, whence we conclude that these bodies are present in the substance of the sun itself, from which they have been volatilized by heat. The moon and planets have spectra like that of the sun, because they shine by its reflected light, while, on the other hand, each fixed star has a spectrum peculiar to itself. It has been already stated that the incandescent vapor of each elementary substance has a characteristic spectrum, consisting of fixed lines, which never changes. Spectrum analysis, as this is called, furnishes the chemist with an exquisitely delicate test to enable him to detect the presence of minute quantities of elementary bodies. For instance, by heating any substance until it becomes gaseous and incandescent, he is able by means of the lines to read off from the spectrum the various elements present in the vapor. By this means several new elements have been discovered.*

Photography has been of very great assistance to the spectroscopist by the means it has given him of not only making rapid and correct representation of the spectrum lines, but also in showing him a number of lines of very great importance situated in the ultra-violet parts of the spectrum, and which are totally invisible to the eye. In return for this assistance, spectroscopy has been of great value to photography. In the very earlier days of photography the action of the spectrum upon substances sensitive to light was studied. Indeed, before that period, and as far back as 1777, Scheele showed that the violet rays of the spectrum had the greatest darkening action upon silver chloride.

The effect of the spectrum upon photographic sensitive surface is very different from what is apparent to the eye. For instance, yellow and green appear the clearest to us, but the photographic plate is hardly affected by them; but it receives a powerful impression from the indigo and violet rays, which appear dark to our eye, and even from rays that are quite invisible to us. Hence it is not difficult to understand that many-colored objects are represented by photography in a false light. This has been partly remedied by the introduction of the orthochromatic process. By means of so-called ray sensitizers the plate can be made more sensitive to the yellow and red rays and give true representations of colored objects. (See **Orthochromatic Photography.**

A careful study of the action of the spectrum colors enables us to discover the safest light with which we can illuminate the dark-room for convenience in working. (See **Non-actinic Media.**)

SPECTRUM ANALYSIS.—See **Spectrum.**

SPHERICAL ABERRATION.—See under **Aberration.**

SPENOXYLYIC ACID.—See **Salicylic Acid.**

SPIRIT LEVEL.—See **Level.**

SPIRIT PHOTOGRAPHS.—The production of phantom-like images by means of photography, although very simple, has often been used to gull the weak-minded believer in supernatural visitants. In the old wet-collodion days photographers were often troubled with spirit images, as the glass of old negatives was used over again, and in some cases a chemical action had taken place between the old image and the glass, impressing itself upon the latter, and showing as a hazy figure in the positive of the second image made upon the plate.

FIG. 425.—"SPIRIT" PICTURE.

The usual method of preparing spirit photographs is the following. The spirit may be prepared on the plate either before or after the exposure of the sitter. In a room made perfectly dark the draped figure to represent the spirit is posed, in a ghost-like attitude, in front of a dark background. With suitable lamp, light is thrown upon the figure. Next a fine piece of muslin gauze is placed close to the lens, which gives a cloud-like, indistinct appearance to the image. The exposure is made,

* From Annandale's Cyclopædia.

and the latent image remains upon the sensitive plate, which is again used to photograph the sitter, with the result that on development the two images are made to appear at the same time, so that the sitter imagines that the spirit must have been hovering around him at the time the photograph was made. By such means a variety of effects can be made—spirits floating in the air, mysterious hands, etc.

SPIRITS OF HARTSHORN.—See **Ammonia.**

SPIRITS OF SALTS.—See **Hydrochloric Acid.**

SQUEEGEE.—A handy contrivance consisting of a strip of flat indiarubber set in a wooden back or handle. It is exceptionally useful for pressing the front in contact when mounting for carbon printing, for glazing gelatine prints, etc., where an even pressure is required. The indiarubber should be neither too hard nor too soft, and it should have an even and perfectly straight edge.

Another form is that known as the roller squeegee. It consists of one or two wooden rollers, covered over with indiarubber and set in a handle. Its purpose is the same. See Figs. 426, 427.

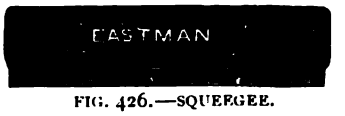


FIG. 426.—SQUEEGEE.

FIG. 427.—ROLLER SQUEEGEE.

STAINS.—Stains are usually due to careless manipulation. Pyro stains on negatives developed with that substance can usually be removed with—

Chrome alum	1 ounce
Citric acid	1 ounce
Water	20 ounces

This solution also is useful for clearing negatives or bromide paper developed with ferrous oxalate.

Silver stains upon negatives which sometimes make their appearance if the paper or negative be damp when printing are very difficult to remove. Remove the varnish and apply—

A.

Ammonium sulphocyanide	½ drachm
Water	1 ounce

B.

Nitric acid	½ ounce
Water	1 ounce

A freshly-mixed solution is used for each negative. Afterwards wash well, and immerse in a saturated solution of chrome alum.

Silver stains on the hands may be removed with—

Sodium sulphate	½ ounce
Lime chloride	½ ounce
Water	1 ounce

Mix up well, and apply with an old hard toothbrush.

Pyro stains on the fingers are removable by well washing with a 10 per cent. solution of oxalic acid.

To remove nitric acid stains from the hands or clothes, touch them with a solution of potassium permanganate, wash well in dilute hydrochloric acid, and again wash.

Black stains with ferrous oxalate development will sometimes occur if the plate be handled with fingers contaminated with sodium hyposulphite. There is no method of removing them. Yellow stains on prints, after fixing, are generally due to their having stuck together when in the hypo. Some of the silver hyposulphite has not been removed, and changes in the washing waters to silver sulphide, producing yellow stains. Use fresh hypo for each batch of prints.

Dr. Eder has made several experiments with thiocarbamid for removing yellow pyro stains and for preventing green fog, which sometimes makes its appearance on plates developed with amidol. The solution he employs is :

Water	1000 c. cm.
Hyposulphite of soda	200 grammes
Thiocarbamid	15.20 grammes

To this solution is added :

Acid sulphite lye	30 c. cm.

Or

Sodium bisulphite	50 grammes

Negatives must be well washed before fixing.

STAMP PHOTOGRAPH.—Small photographs made with a design and gummed at the back to resemble postage stamps, (see Fig. 428), and are used for many purposes, such as trade marks, business cards, letter heads, etc.

By an arrangement similar to that shown in Fig. 429, a cabinet picture is placed behind the matt or border and a negative made. No focusing is required, and there are usually 12 or 16 lenses so that many images are formed. From the negative thus obtained silver prints are made. The pictures are then given perforated edges and gummed at the back to resemble postage stamps.

FIG. 428.
STAMP PHOTOGRAPH.

FIG. 429.—CAMERA FOR MAKING STAMP PHOTOGRAPHS.

STANDARD GOLD.—A mixture of metal containing 11 parts of pure gold with one part of alloy, *i.e.*, 22 carats fine with 2 carats of alloy.

STANDARD SILVER.—A mixed metal containing 37 parts of pure silver and three parts of alloy.

STANDARD SIZES—See **Sizes.**

STANDARD SPIRIT.—A mixture of alcohol and water having a sp. gr. of ·92 at 62 deg. Fahr. It contains nearly equal parts of absolute alcohol and water.

STAND, CAMERA.—See **Camera Stand and Tripod.**

STANNOTYPE.—This process may be termed a simplified Woodbury process. On reference to the description of the latter, it will be found that one of the principal requirements is a costly hydraulic press, with which to form the printing mould by pressing the gelatine relief into the lead surface. The object of the stannotype process was to do away with this costly machinery, and bring the process within the reach of all. A careful consideration of the principles involved in the Woodburytype process will show that if a gelatine relief were produced from a positive instead of a negative, this relief would serve as the printing mould in the same manner as the impressed lead, were it not for one serious drawback, and that is, that being of gelatine it would be destroyed when it received the necessary wetting. This drawback was overcome by Woodbury after a long course of laborious experiments by a most simple expedient. It was simply by protecting the relief by means of a sheet of tinfoil, pressed well into contact with it.

The first thing necessary in the preparation of the relief is a positive transparency. This can be produced by any of the well-known methods, that process being most suitable which gives the greatest range of density. This transparency, it should be noted, must be reversed as regards right and left, unless the picture is one that can be printed reversed without being noticeable. The single-transfer carbon process is the one generally used, the image being intensified with potassium permanganate. Finally, the transparency should have an edging of clear glass about ⅛in. width, and the highest light should be quite clear.

The transparency having been made, the relief is next made from it, as in the Woodburytype process. This may also be done by laying a piece of moist paper upon a sheet of glass, and coating it with a gelatine solution; when set, both are detached from the glass and hung up to dry. It is afterwards sensitized in a bichromate solution and printed from with the positive. If paper be used as the support, the side farthest from the paper is, of course, brought into contact with the positive, and that side is afterwards attached to glass, either by means of an indiarubber solution, or by coating the glass with gelatine containing a little bichromate solution, and drying the film in the sunlight.

By whatever means the relief is produced, it should, after being developed, be allowed to remain upon the glass plate, which should be plate glass and rather thick.

The next operation is the protection of the relief with the tin-foil. If only a few hundred copies are required to be printed, ordinary tinfoil will do, but if a large quantity are necessary, special steel-face foil must be employed. The tinfoil must be of perfect quality and free from pinholes. These may be detected by holding the sheet up to a strong light, and any piece containing them should be instantly rejected, as the smallest hole will allow the gelatinous ink to wet the relief beneath, and produce a white spot, if nothing more serious.

A piece of the perfect foil, a little larger than the relief, is laid on to a clean sheet of glass, and carefully flattened and rubbed out smooth with a velvet pad. Those used for brushing silk hats are very serviceable for this purpose. The relief is then prepared to receive it. The edging, which is in high relief, is first coated with a thick solution of rubber in benzine, and when this is set the whole surface is flowed with a thin solution of rubber. Burton recommends gum para, a

good strength of solution being two grains to the ounce. Pure benzine will serve as a solvent, although chloroform is much preferred. When this indiarubber film has set, the tinfoil is laid carefully over it and pressed well into contact with the velvet pad, and then the plate holding the relief and foil is passed through two rubber or rubber-coated rollers. The domestic wringing machine, fitted with indiarubber rollers, serves excellently for this purpose. The rollers are separated, and the plate inserted, so that the rollers cross the center of it. Pressure is then applied, and the plate moved backwards and forwards so that the tin face is pressed well into all the parts of the relief. The back of the glass is then cleaned, and the face surface of the now perfect printing mould carefully oiled with a little piece of flannel with a drop or two of mixture of olive and paraffin oils. The mould is then ready for printing from in the same manner as with the Woodburytype process (*q. v.*)

STANNOUS CHLORIDE (Formula, $SnCl_2$; synonym, *protochloride of tin*).—Prepared by dissolving tin in hydrochloric acid and water, equal parts. It is used with chlorine water as a test for gold, forming the so-called purple of cassius.

STARCH (Formula, $C_6H_{10}O_5$; molecular weight, 162; synonym, *amylose*).—Commonly made from rice. When starch is heated with water to about 122 deg. F., the granules begin to burst, which is completed at 158 deg. F., when the granulose is dissolved to a viscous liquid, which becomes a jelly on cooling. In this form it is used in photography for mounting purposes. It is also used as a size for paper.

STARCH PASTE.—See **Mountant.**

STEATITE.—See **Chalk.**

STELLAR PHOTOGRAPHY.—See **Astronomical Photography.**

STEREOCHROMOSCOPE.—A form of stereoscope which enables reproductions of objects to be seen stereoscopically, in their natural colors. It consists primarily of an ordinary stereoscope, such as everybody is familiar with. The two stereoscopic images, placed axially to the oculars, are viewed by means of colored screens, the one by a translucent red glass, the other by blue. It should be said that the positive chromograms are reproduced in the same way as is required for examination in the photochromoscope of Mr. Ives, that is, each one only reproduce certain color sensations. It is necessary, in order that the synthesis of the colors should be complete and satisfactory, there should be a combination of three images, so that, in addition to the red and blue, it becomes necessary to have a green positive. Of course, the two vertical stereoscopic images have the same differences as regards points of view and inclusion of subjects as characterize ordinary stereographs. The third image is placed horizontally in the base of the stereoscope at right angles to one of the vertical images. An opening in the base permits the light reflected from the mirror C D to traverse the green screen and the superposed positive. See Fig. 430.

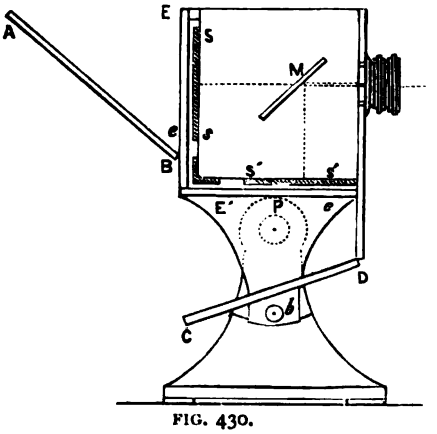


FIG. 430.

Behind the prisms is placed a platinum mirror, which reflects the horizontal image on the vertical image, so that the eye which looks through, say the right prism, sees two colored positives, namely, the red and green and a combination of the two colors. The other eye, however, sees only the blue positive, but this, by reason of stereoscopic convergence, is superposed, as it were, on the other image, so that only one image is ultimately seen, and that in relief and colors. The above diagram will give an idea of the system employed. Essentially the stereochromoscope is a rectangular box of the usual type, carrying on its face two prisms forming the oculars. It rests on two supports, being pivoted at P, and held by the button P in the best position for receiving natural or artificial light on the mirrors A B and C D. M is the platinum mirror referred to, the positives are placed at S *s* and S *s'*, and the colored screens at E *e*, and E' *e'*. The two images at S *s* in combining give the sensation of one solid image, and, as the images are seen against the colored screens placed at E *e* and E' *e'* the combination of colors takes place at the same time. It will be seen by the construction of the stereochromoscope that it allows of the examination of four as well as three positives.*

STEREOGRAPH.—The representation of a solid on a plane. A stereoscopic slide.

STEREOMONOSCOPE.—An instrument with two lenses by which an apparent stereoscopic effect can be obtained from a single picture.

* The British Journal of Photography.

STEREO-PHOTO-DUPLICON.—An instrument enabling stereoscopic views to be made with a single lens. The complete instrument, as in Fig. 431, is fitted with a shutter, giving time or instantaneous exposure. The stereoscopic portion of the apparatus is furnished with spectrums manufactured expressly for the purpose, giving absolutely perfect reflections. The principal of their arrangement is shown in Fig. 432, wherein the camera is represented at D, the lense at C, and the spectrum, at A A and B B. The dotted line at E E, indicates the position of the object to be photographed, a view of which is taken from two different points equal to the separation of the eyes, by reflection from the two mirrors A A to the center mirror B B, and from thence through the lens of the camera to the plate.

It will be seen by reference to Fig. 432, that transposition of the two views is effected; it may be supposed that this reverses the views, but this is not the case, while transposition takes place, both views are taken in their correct positive; thus a negative is produced which may be printed from direct, without the trouble of having to transpose the prints, or cut and remount the negative.

FIG. 431.—STEREO-PHOTO-DUPLICON.

FIG. 432.

STEREOSCOPE.—If a solid object be viewed from a short distance by both eyes on whatever point they are fixed, that point will be seen the most distinctly and other points more or less clearly. But, owing to the different positions of the two eyes, it is quite apparent that the images seen by them differ slightly from one another, and it is by the union of these two pictures that we see the object and know it to be solid. If, therefore, we draw or photograph this object first as seen by the right eye and then as seen by the left eye, and present each eye to that picture which was made from its point of view, we see the representation of the object in relief almost as we see the object itself. Fig. 433 proves this. If the two representations of a truncated pyramid, as seen by the right and left eye, be steadily looked at R with the right eye and L with the left, holding a piece of card between the fingers to separate them, we get a single picture of the object in relief. To assist the eye in combining such pairs of dissimilar pictures, mirrors and lenses have been used, such instruments being termed stereoscopes.

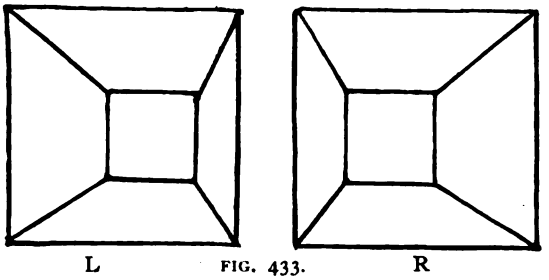


FIG. 433.

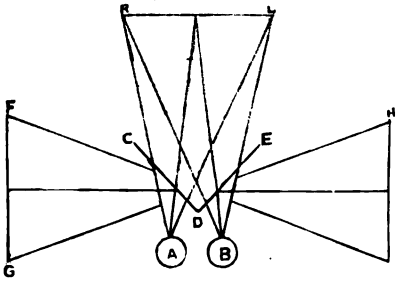


FIG. 434.—DIAGRAM OF REFLECTING STEREOSCOPE.

The first stereoscope invented by Wheatstone has been termed the reflecting stereoscope for the reason that mirrors or reflectors are used to change the apparent position of the pictures, so that they are both seen in the same direction. Two mirrors about three inches square are arranged so that their backs are at right angles to each other as shown in Figs. 434, 435. The two pictures are reflected by the two mirrors into the right and left eye respectively, and appear as only one picture. As, however, the picture was in-

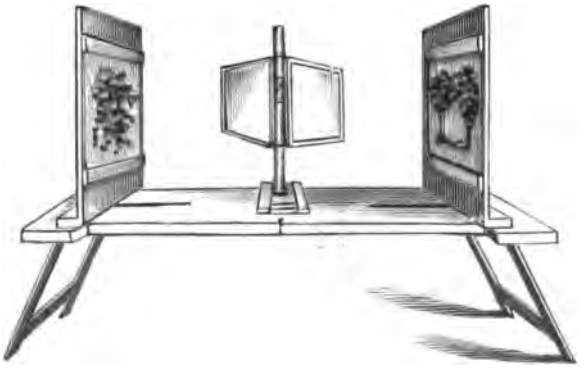


FIG. 435.—REFLECTING STEREOSCOPE.

verted by the mirror, it was necessary to place the drawing for the right eye on the left side, and the one for the left eye on the right side.

To Sir David Brewster is due the credit of the invention of the lenticular stereoscope, so called to distinguish it from Wheatstone's instrument. In Brewster's instrument another means is made use of to compel each eye to see its own picture. This is done by lenses divided in half and inverted (figs. 436, 437). His method is thus described:*—

"If an object be viewed through the center, or more properly, along the axis, of a convex lens, it will be seen exactly in front of the eye—*i.e.*, in a line with the eye, the center of the lens, and the actual place of the object. If now the lens be moved slightly to the left, the object will appear to advance to the right; and conversely as the lens is moved to the right, the object is displaced in the opposite direction. Let the lens be cut in half tranversely, and the two semi-circular pieces reversed as to their former position—that is, placed side by side, and so that their thin edges shall be adjacent, while the two plane edges formed by the section of the lens are kept in mutual parallelism and have their faces turned outwards towards the left and right respectively. The right eye will now look through the left half of the lens, and *vice versa*, and the two pictures, each placed opposite its appropriate eye, and in the principal focus of the eye-piece, will be seen, not in their actual places, but in a position midway between the two. The subsidiary purposes served by this arrangement are, that the pictures are magnified as well as caused to coalesce, and that the equality of the magnifying power of the eye-pieces (a result by no other means certainly attainable) is secured by the fact of their being cut from the same lens, the whole of which is thus advantage ously and economically utilized."

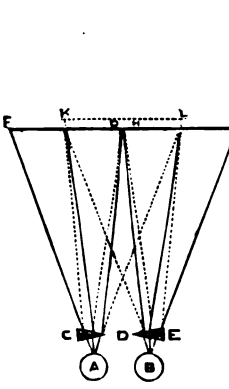


FIG. 436.

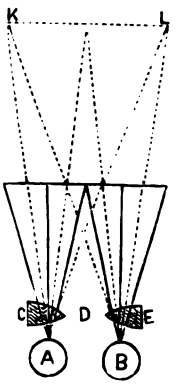


FIG. 437.

Various forms of stereoscopes are shown on p. 473.

STEREOSCOPIC PHOTOGRAPHY.—The art of stereoscopic photography was practised some years ago, and held public attention for some twenty years or more, after which it gradually died away. Many attempts have of late been made to revive it, and it is quite possible that with the new appliances and the better understanding of the theory, it will again receive much attention.

When an artist wishes to make a representation of a solid body, he adopts various means—by the shading and lighting; in architectural work by geometrical perspective, and in landscape by both these, and also by what is termed aerial perspective. Although by this means the effect is often very good, the illusion is far from being complete, as it is rarely possible to mistake the painting for the solid object itself. By closing one eye, and viewing a painting or photograph with the other, the effect of solidity is considerably increased. When, however, we see a natural object with both eyes at once, our eyes being about two and a-half inches apart, a little consideration will make it plain that we in reality see two images from slightly different points of view. The right eye sees rather more of the right side, and the left eye rather more of the left side, yet our brain and our vision work together, so that we do not usually see objects double, but single. This is what is termed binocular vision, an effect no single painting or photograph can possibly produce.

FIG. 438.—STEREOSCOPIC CAMERA.

In the production of stereoscopic photographs we endeavor as far as possible to imitate nature in her provisions for enabling us to see objects with a certain amount of roundness or solidity, and to permit us also to better realise the distances between various objects situated on different planes.

For producing stereoscopic photographs special twin cameras are constructed (see fig 438). In the earliest days, however, a single camera fitted with only one lens was used. An extra baseboard was provided, upon which the camera was moved from between two and a half to three inches to one side between the first and the second exposure. Although by this means the same effect was, and is still, often produced, yet this method has several drawbacks. For instance, objects in motion and instantaneous effects cannot be made with the single lens. The modern stereoscopic camera is fitted with two lenses side by side, their centers distant about three inches, and their foci equal. These are generally termed twin lenses. A partition runs down the center of the camera interior to separate the views from the two lenses, and form as it were two distinct cameras.

* "The Stereoscope." G. V. Blanchard.

The usual size of a stereo plate is $6\frac{3}{4}$ x $3\frac{1}{4}$ inches, but, provided the centers of the mounted prints are not more than three inches apart, the height need not be limited to $3\frac{1}{4}$ inches. Mr. J. Traill Taylor recommends for stereo work a plate 8 x 5 inches. Another well-known practical worker, Mr. W. I. Chadwick, considers the best size of negative plate to be $6\frac{1}{2}$ x $4\frac{1}{4}$, a standard known as double quarter being half a whole plate, and double the size of a quarter plate.

FIG. 439.—CABINET STEREOSCOPE WITH MAGAZINE OF PICTURES.

With regard to the lenses, if required for all-round work, rapid rectilinears will be found the most useful. For landscape work, without straight lines, single lenses give the best effect. They should be mounted carefully on the same horizontal plane. The question of the correct space that should be allowed between the two is a disputed one. Our eyes being about $2\frac{1}{2}$ inches apart, this is usually the correct distance to get the the natural effect, but for most landscape subjects this can be increased to three inches. The greater the distance between the two lenses the greater the relief; but this effect can be carried to extremes, producing an unnatural and exaggerated effect. The lenses should be of equal foci, and with perfectly similar diaphragms for each otherwise one picture will be more exposed than the other. Iris diaphragms are too indefinite for this purpose.

A little thoughtful consideration will show that if the two halves of the stereoscopic picture are taken on one plate, these two halves will have to be transposed if the image is required to be seen stereoscopically. They can, of course, be transposed on the plate itself by taking the right, view on the left of the plate and the left on the right, but arrangements for this are rarely made now, the cameras being what are termed "binocular," consisting practically of two cameras side by side, making two pictures upon one plate at the same time. With this camera, therefore, if we hold the negative up before us in the same position as it occupied when in the camera, we have the picture taken with the right hand lens on our right hand, and that made with the left lens on our left. But when from this negative we make our positive prints we invert this arrangement, and the right hand picture is on the left, and, therefore, to get into correct position again, the double print must be cut through the center, and the two pictures divided and transposed. If this be not done, and the pictures viewed thus in the stereoscope, we get an opposite effect to stereoscopic, an effect which has received the name "pseudoscopic," or false sight.

FIG. 440.—STEREOSCOPE.

Very considerable care is required in cutting and mounting stereoscopic pictures, or stereograms, as they are termed. The first thing is to determine a base line. The cutting edge is laid down on the double print, and the knife drawn along, so that it cuts a given object in the foreground of each half at exactly the same point.* The top of the print is then trimmed parallel to this base line. The two halves are then separated and transposed. The sides of the pictures are then trimmed on the print that is to be mounted on the right hand side, more subject on the right than we leave on the right of the left hand picture; and on the left hand picture we must leave more of the left side than we leave on the left of the right hand picture. The pictures are then mounted so that their centers shall be not less than two and three-quarter inches nor more than three inches apart.

Stereoscopic pictures should be printed to full depth, and should be full of detail. Flat prints, wanting in vigor, often look best in the stereoscope.

It is an indisputable fact that stereoscopic transparencies are a long way superior to prints, therefore this portion would be very incomplete without some remarks concerning their manufacture. The simplest method is by contact printing. The negative may be cut and transposed, or it may be printed from in an ordinary printing frame, and the transparency cut and transposed, and bound up between two cover glasses.

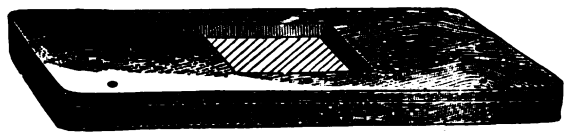


FIG. 441.—PRINTING FRAME FOR STEREOSCOPIC TRANSPARENCIES.

The best plan, however, is by means of a special printing frame, shown in the accompanying sketches.† The principle of the frame is to print each picture separately, and at the same time to effect the necessary transposition by printing the left-hand side of the negative on the right hand side of the transparency plate, and then to transpose the negative and plate, and print the right end of the negative on the left of the transparency plate. The working of this frame is

*For this purpose it is absolutely necessary that the camera be held level when exposing the plate by means of a tripod stand; hence the failures that so often attend stereoscopic pictures made by detective or hand cameras. †From "Chadwick's Stereoscopic Manual."

thus given.* The front of the frame (fig. 441) is of solid wood, with an aperture in the center, through which the printing is done. The frame should be 10½ in. long *inside*, the aperture two inches and seven-eighths wide, and exactly in the middle. In fig. 442 the negative shown by diagonal lines has been placed in the frame film side up, and adjusted with its left side over the aperture. The sensitive transparency plate is shown by horizontal lines, adjusted with its right end over the negative, and the aperture in the frame. The back (fig. 443) is now placed in position, held by the spring and two holders shown in figs. 442 and 444. After exposure the relative position of negative and plate must be changed, as shown in fig. 444, where the right end of the negative and the left end of the transparency plate are now over the aperture and ready for the second printing When adjusting the negative for the first printing, as in fig 442, observe some particular object—say the edge of a stone, or something of the kind in the foreground *that is cut by the left* side of the aperture—and by a piece of cardboard to serve for a guide the plate is applied in such a position that the center of it is cut by the left edge of the aperture. The back of the frame is now applied and printing performed. We now remove the sensitive plate, refresh our memory with "the stone in the foreground," and slide the negative to the position, as fig. 444, adjusting the particular "stone in the foreground" as for the previous printing. Apply the plate by use of the guide, which is now turned to the other end, and if made correctly will produce the two pictures side by side, with a clean cut line between them without any space or overlapping.

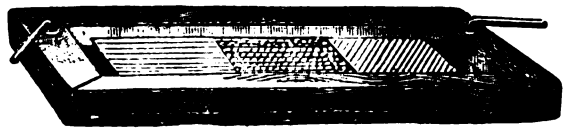


FIG. 442.

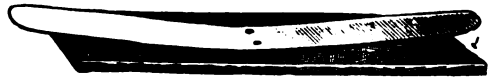


FIG. 443.

In printing from large negatives the printing frame must, of course, be made correspondingly larger, and provided with suitable guides, enabling various portions of the negative to be printed from.

The plates used for the transparencies should be those specially prepared for that purpose; several excellent kinds are now in the market. When finished the transparency is filled with a paper mask, with openings at 2¾ centers, and a cover glass. The whole are then bound up together with gummed edging paper. To view correctly, the film side must, of course, be nearest to the observer, the cover glass acts as a protector. Some place a ground glass behind the transparency, but this should be very thin. (See also **Transparency.**

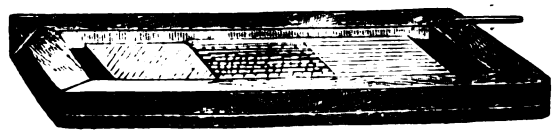


FIG. 444.

A copying camera for making stereoscopic transparencies from stereoscopic negatives without cutting the negative is shown in fig. 445.

Midway between the ends of the camera is a frame which divides the body of the camera in two parts. A door at the side (H) gives access to the inside. On a hooded front (B), with a flap shutter, is screwed a pair of 5 or 6 inch lenses. The front carrying the lenses is so arranged that the lenses may, by means of screws (D), be brought nearer to each other or farther apart. If it is intended that the transparency be a little smaller or larger in scale than the negative, the bellows in front and rear of this frame permits the same to be accomplished.

To practically illustrate: In the front of camera (A) button a ¾ stereo negative, placing it upside down and film side in. Move the center portion with the lenses back from the negative, so that from the top of the lens to the negatiue will be twice the focal length of the lens in use. Clamp this section, and move the ground glass back until the distance from ground glass to stop of lens equals twice the focus of lens in use. Adjust the ground glass until the image on the same is sharp, then tighten all clamp-screws.

A, Stereo negative. B, Hooded front, covering lenses. C, Mill-head for raising flap-shutter. D, Screw for moving right-hand lens. E, Set-screw for vertical sliding-front. F, Ground glass. G, Holder. H, Door.

FIG. 445.—STEREO TRANSPARENCY CAMERA.

The diaphragm at back of camera gives the size of the two images, being 3¼ inches high by 3 inches wide. Inside the rear bellows is placed a bellow division separating the light from the two lenses. The sliding front of camera carrying the negative should now be moved up or down in order to fix a base line for the picture, which will be an imaginary line drawn across the negative and passing through two sim-

* W. I. Chadwick.

ilar objects in the two halves of the negative. This settled, then, by means of the milled head screw, move the right-hand lens so as to bring some object, as a tree, corner of a house or fence, that it may be close to the side of diaphragm; then move the other lens so the same object will be ⅛ of an inch from the other diaphragm.

These points settled, place a ground glass transparency plate, 3¼x6¾ inches, in the holder, and adjust it to the camera. Place fairly small stops in the lenses; close the flap-shutter by means of the milled head (C), draw slide to holder, point camera to the sky; then raise the flap-shutter, and give one, two or three seconds, according to circumstances. After developing, fixing, washing and drying, the face is covered with a thin piece of glass and the edges bound, when the transparency is ready for the stereoscope.

STILL.—An apparatus for distilling water or other liquids. A simple form is that shown in fig. 446.

The water or liquid to be distilled, is placed in a glass flask, the neck of which is connected with a long glass tube which is surrounded by an outer jacket of glass or tin through which cold, water must be continually kept flowing. This piece of apparatus is known as Liebig's Condenser. The end of the glass tube is placed within a flask known as a receiver because it receives the condensed liquid. The water in the retort is heated with a Bunsen burner; the steam given off passes through a condenser; it is then cooled and the distilled water is collected in the receiver. When large quantities are required the still is made of copper and the tube of tin made in a spiral form (see fig. 446).

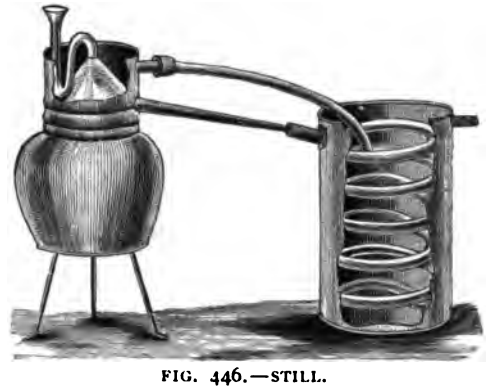


FIG. 446.—STILL.

STOP.—A disc of blackened metal or other material having a central aperture of such a size as to allow the rays of light to pass only through that portion of the lens that it is determined to use. For this reason the stop must be placed quite close to the lens. (See **Diaphragm.**)

STOPPER.—Stoppers of glass bottles are usually made to fit by grinding them in the neck of the bottle with a little fine emery powder paste. There are many chemicals used in photography which require to be kept in tightly-stoppered bottles, as corks would be gradually destroyed. One of the most annoying things with these is the liability of the stopper to stick fast in the bottle, defying all ordinary methods of removal. The best method to remove a tight glass stopper is by tapping it gently on one side with a light wooden handle, and at the same time you hold the bottle in the other hand you press the stopper on the other side upwards. Another method is to wrap a cloth dipped in boiling water round it, and thus expand the glass, or the same effect can be had by means of a piece of string passed once or twice round the neck and drawn rapidly backwards and forwards, holding the bottle firmly the while. The following method is given by a correspondent to *Photography*:—

"Put two or three drops of paraffin oil in the recess between stopper and bottle. This will, in a short time, insinuate itself through the 'sticking' place. In the meantime prepare, two pieces of hard wood, say ash, about 9 in. long by 1 in. wide and ¾ in. thick. Bind them at one end with a leather hinge (a bit of good thick 'upper' off an old shoe will do well), nail it very securely, and glue a strip along the inner edges, say 5 in. long. You have then an instrument somewhat like a pair of crude nutcrackers. Put this on your stopper, grip it tight with the hand, give a few wriggles, and then a firm, slow turn, and your stopper is certain to give way to this persuasion. The leather lining is to soften the pressure and prevent slipping, and the length is for leverage. You can wipe the oil out of the neck before it can run into the contents of the bottle."

Prevention is always better than cure, we know; therefore, all stoppers should be anointed with a little vaseline, which will effectually prevent sticking, and has no injurious action upon the contents.

STRIPPING FILM.—Paper coated first with a solution of soluble gelatine, and then with a sensitive gelatine emulsion as used for dry plates. The paper acts as a temporary support during the operations of exposure, development, fixing, and washing, after which the film is laid face downwards on a prepared sheet of glass, and the paper removed with warm water, which dissolves the soluble layer, and leaves the image-bearing film upon the glass. The temporary paper support is then replaced by a prepared sheet of gelatine called a stripping skin, and the whole stripped, when dry, from the glass. This process gives a clean, transparent flexible negative of superior printing quality, having all the advantages of glass without its fragility, and about one-

fiftieth of its weight. These negatives can be printed from both sides equally well, and are therefore very suitable for the carbon and photo-mechanical processes. The process of developing and fixing is precisely the same as with a dry plate. No alum bath should, however, be used previous to stripping. The following instructions are given by the Eastman Co. for stripping their film: While the films are washing, clean a glass plate one half-inch larger all round than the negative, and free from surface defects, and flow over it a thin layer of rubber solution, draining away all excess, and allow the surface to dry (say, for five minutes), then coat the plate with a plain collodion. The moment the collodion sets, wash well in cold water until the water runs from the surface without any appearance of greasiness, then place the collodionized plate face upwards in a dish of cold water, and bring into contact with it under water the paper negative film side downwards; grasp the plate and film by one edge with the finger and thumb, and lift the glass with the film attached slowly, allowing the water to drain from the opposite side. Lay the plate upon a table and place upon the back of the paper negative a smooth side of an indiarubber cloth (larger than the glass) and remove all surplus water by the action of a squeegee. The squeegee should be used firmly but without violence, the motion being in all directions. Remove the rubber cloth, lay the plate with the film upwards on a table, and place upon the film a double thickness of stout, clean, blotting-paper. Place a board or other flat surface over the blotting-paper, and on the board a weight of a few pounds. Proceed in like manner with all the washed films, always piling the last plate on the top of the blotting-paper covering the previous plate, and always place on top the blotting-paper, the board and the weight. In fifteen minutes the first plate will be ready to strip, but a much longer period may elapse if desired, provided the collodion varnish is not permitted to dry. The films will, however, strip perfectly after a lapse of several hours, if kept as directed.

Into a flat dish put water at about 120 deg. to 200 deg. Fahr., and, face upwards, in this immerse the first (or bottom) plate. Rock the dish slightly, and in a minute or two the paper will be found wholly or partly floating in the water. Remove it entirely with care. Remove from the film with warm water and gentle friction with a soft hairbrush, or the soft part of the hand, any of the soluble gelatine that may remain attached to it. Wash well with cold water and immerse, if necessary, in the

CLEARING BATH.

Saturated solution common alum in water	20 ounces
Acid hydrochloric	1 ounce

And if intensification is necessary, soak the negative in a saturated solution of corrosive sublimate, wash well, and blacken the image with a solution of 10 drops of strong ammonia to one ounce of water.

All intensified or cleared negatives should be very carefully and very thoroughly washed in running water or in frequent changes of water for not less than two hours.

In a flat dish soak one of the stripping skins in cold water (in very dry climates soak in a bath of water containing five per cent. of glycerine and a few drops of carbolic acid. Place the plate under the skin in water and bring the skin into contact with the negative. Grasp the skin by the edge with the finger and thumb and lift slowly, allowing the water to drain from the opposite side. Remove all surplus water by the gentle action of a squeegee. Set the plate aside to dry gradually, say, for four or five hours at ordinary temperature. Trim the edges of the negative with the point of a sharp knife and strip it from the glass. Adhering rubber solution may be removed from the face of the negative or the glass by a tuft of cotton-wool saturated with benzine.

It is of the utmost importance that the stripping skin should not be soaked too long—otherwise the glycerine will be entirely removed, and the finished negative will be hard and brittle, two minutes should be amply sufficient.

The back of the dried stripping skin may be coated with collodion before the negative is removed from the glass if thought desirable, or if a varnished negative is not required, the use of the collodion varnish may be dispensed with entirely.

Solutions used in developing the films should not exceed 75° Fahr., and the hands should only touch the films at the corners while wet to prevent softening of the soluble gelatine layer which holds the film to the paper.

For photo-mechanical printing processes and carbon single transfer, the negatives may be printed from while on the glass.

Printing from stripped film negatives may be done from either side if required, but the side that was in contact with the glass at the time of transfer is the correct side. The negative should be laid (preferably) on the convex side of finely-ground glass in the printing frame, ground side next to negative. This method gives fine soft effects, and prevents mottling of the print, caused by partial contact of the negative with the glass.

Gelatine films can be stripped from the glass plate by immersing in a weak solution of Hydrofluoric acid, Fluoride of sodium or of potassium. To prevent distortion of the image it is advisable to previously coat the film with a five per cent. collodion.

STRIPPING FILMS (Collodion).—Negatives produced by the collodion process can be stripped from the glass support without much difficulty. The following is the *modus operandi:* The glass plate must be well polished and rubbed over with French chalk, and then polished again. It must not be albumenized. When the negative is dry strips of thick paper are pasted along the four sides, either with starch or a solution of gum tragacanth. It is then slightly warmed and placed on a previously levelled stand, and a warm solution of gelatine poured over it, sufficient to give a fairly thick film. This gelatine solution is made up as follows:—

Gelatine	2½ ounces
Sugar	1½ ounces
Water	20 ounces

And is prepared by first soaking the gelatine in water until quite flabby, and then placing the vessel containing it in hot water until the gelatine is thoroughly dissolved, when it is strained through muslin and is ready for use.

In coating, a small quantity is poured over the levelled plate and spread evenly all over with a Blanchard brush or other similar contrivance. When the film is set the negative is removed and placed in a current of cold air until the film is quite dry. When thoroughly dry all that remains to be done is to run the point of a sharp penknife all round the edges underneath the paper strips, and the negative film will leave the glass plate with a brilliantly polished and flat surface.

Old collodion negatives can be stripped sometimes, but the operation is undoubtedly a risky one, as there is always considerable chance of spoiling it during the operation. If the negative be a valuable one a good positive transparency should always be made before attempting the operation.

The varnish is first removed and the paper pasted round; the plate is then levelled, coated with gelatine, dried, and stripped in the same manner as already described.

STRONTIUM BROMIDE (Formula, $SrBr_2$; Synonym, *bromide of strontium.*)—Prepared by neutralizing hydrobromic acid with strontium hydroxide. It crystallizes in small tablets, soluble in water, and sparingly so in alcohol. It is employed in the manufacture of some collodion emulsions.

STRONTIUM CHLORIDE (Formula $SrCl_2+6H_2O$).—Synonym, *chloride of strontium* Occurs in deliquescent prismatic crystals soluble in water, feebly soluble in alcohol. Employed in the manufacture of collodio-chloride printing out emulsions.

STRONTIUM IODIDE (Formula SrI_2).—Forms yellowish-brown needles, soluble in water and alcohol. Sometimes used as an iodizer for collodion.

STUDIO.—The old-fashioned idea that any room with a top and side light constituted an efficient studio has long since been abandoned, and considerable attention is now paid by photographers in the construction of the studio, so as to get the best results. Locality is an important point, as the quality, not the quantity or intensity, of the light is the important point. The usual instructions are that one part should be open to the north, another to the east, a third to the west, and the south side should be closed. In some cases, however, a side light will be impossible; care should then be taken that the inclination of the top light is towards the north. Every attempt should be made to facilitate and perfect the lighting of the model. There is more art in this than many imagine. A soft light is what is necessary.

The skylight should be perfectly rain-proof, and arranged with adjustable blinds, enabling the operator to reduce or increase the amount of light from any part.

Various other contrivances are used for arranging the light upon the sitter, such as hand screens, reflectors, curtains, screens in frames, etc.

The accessories should be carefully and cautiously chosen. The fearful and wonderful furniture never seen outside a photographer's is gradually being discarded, and the best photographers are beginning to find that the finest results are obtainable with the most simple accessories.

The length of the studio must be in accordance with the length of the focus of the lenses employed and *vice versa.* The accompanying table* gives the minimum length of studio for lenses of various foci to obtain images of different sizes.

STUDIO CAMERA.—See **Camera.**

STUDIO STAND.—See **Camera Stand.**

* From *The American Amateur Photographer.*

TABLE FOR FINDING THE MINIMUM LENGTH OF STUDIO FOR A GIVEN LENS.

DISTANCES IN INCHES FROM OBJECT TO LENS.

Equivalent Focus of Lens.	3 in. high.	4 in. high.	5 in. high.	6 in. high.	8 in. high.	10 in. high.	12 in. high.	16 in. high.	20 in. high.	24 in. high.	30 in. high.	36 in. high.	48 in. high.	54 in. high.	60 in. high.	72 in. high.
3 inches....	75	57														
4 "	100	76	61⅛	52												
5 "	125	95	77	65	50											
6 "	150	114	92⅜	78	60	49⅛										
8 "	200	152	123⅛	104	80	65 6/10	56									
10 "	250	190	154	130	100	82	70	55								
12 "	300	228	184⅛	156	120	98⅜	84	66	55⅛							
16 "	400	304	246⅜	208	161	131⅛	112	88	72⅜	64	54⅜	48				
20 "	500	380	308	260	200	163	140	110	90⅛	80	68	60	50	46⅛		
24 "	600	456	369⅜	312	240	196⅛	168	132	110⅛	96	81⅜	72	60	56	52⅛	48
30 "	750	540	462	390	300	246	210	165	136⅛	120	102	90	75	70	65	60
36 "	900	684	554⅜	463	360	307⅛	252	198	165⅜	144	122⅜	108	90	84	78⅛	72
48 "	1200	912	739⅛	624	480	393⅛	336	264	220⅜	192	163⅛	144	120	112	105⅜	96
60 "	1500	1080	1024	780	600	492	420	330	272½	240	204	180	150	140	132	120
72 "	1800	1368	1108⅜	936	720	614⅜	504	396	321⅛	288	244⅛	216	180	168	158⅜	144

DISTANCES IN INCHES FROM LENS TO GROUND-GLASS.

Equivalent Focus of Lens.	3 in. high.	4 in. high.	5 in. high.	6 in. high.	8 in. high.	10 in. high.	12 in. high.	16 in. high.	20 in. high.	24 in. high.	30 in. high.	36 in. high.	48 in. high.	54 in. high.	60 in. high.	72 in. high.
3 inches....	3⅛	3⅛														
4 "	4⅛	4⅛	4 5/16	4⅛												
5 "	5 5/16	5 5/16	5 5/16	5 5/16	5⅛											
6 "	6⅛	6⅛	6 5/16	6⅛	6⅛	7⅛										
8 "	8⅛	8⅛	8⅛	8⅛	8⅛	9⅛	9⅛									
10 "	10 5/16	10⅛	10⅛	10⅛	11⅛	11 7/16	11⅛	12⅛								
12 "	12⅛	12⅛	12⅛	13	13⅛	13⅛	14	14⅛	15⅛							
16 "	16⅛	16⅛	17⅛	17⅛	17⅛	18⅛	18⅛	19⅛	20⅛	21⅛	22⅛	24				
20 "	20⅛	21⅛	21 7/16	21⅛	22⅛	22⅛	23⅛	24⅛	25 5/16	26⅛	28⅛	30	33⅛	35		
24 "	25	25⅛	25⅛	26	26⅛	26⅛	28	29⅛	30⅛	32	34	36	40	42	44	48
30 "	31¼	31⅛	32 1/16	32¼	33⅛	34¼	35	36⅛	38¼	40	42½	45	50	52½	55	60
36 "	37½	38	38¼	39	39⅛	40	42	44	46	48	51	54	60	63	66	72
48 "	50	50⅛	51¼	52	53⅛	54⅛	56	58⅛	61¼	64	68	72	80	84	88	96
60 "	62½	63⅛	64¼	65	66⅛	68⅛	70	73⅛	77⅛	80	85	90	100	105	110	120
72 "	75	76	77	78	79¼	80	84	88	92	96	102	108	120	126	132	144

Suppose the lens used is 24 in. equiv. focus, and you wish to make a full-length portrait of a man six feet high, in which the image will be six inches high. Look at the left-hand column for lens focus, and in the top line for size of image. At the intersection of these columns we find 312 inches=26 feet, to be the distance the person must stand from the lens. In the next table, using the same lens and size of image as before, at the intersection of the columns we find twenty-six inches, which represents the distance of the ground glass from lens center. And in the same way any lens and size of image may be computed for.

SUB-BROMIDE OF SILVER.—See **Silver Sub-Salts.**

SUB-CHLORIDE OF SILVER.—See **Silver Sub-Salts.**

SUB-IODIDE OF SILVER.—See **Silver Sub-Salts.**

SUBLIMATE, CORROSIVE.—See **Mercuric Chloride.**

SUBMARINE PHOTOGRAPHY.—What the bottom of the sea looks like is a conundrum which people have tried to solve to the best of their ability during recent years. Of course photography has been called in to render its valuable assistance. What has been done in this direction is given by Dr. J. E. Rombouts in the following article, translated and condensed from *De Natuur:*

"The deep sea explorations and dredgings of late years have certainly shed much light thereon, and have acquainted us with much which, earlier, we would not have suspected could exist at the bottom of the sea.

"Imagination had pictured the bottom of the sea, at least at great depths, as a wilderness, wherein nothing was to be found save the remains of animals which had lived at the surface. Owing to the absence of sunlight it was supposed no life could exist and no color develop.

"We know from what has already been published concerning the deep sea explorations that the state of things at the bottom of the sea is entirely different. We know that there, as well as on the earth's surface, a great variety obtains. That great apparently uninhabited areas alternate with densely populated forest regions—sparkling with every color. No wonder that the attempt has been made to record, by photographic means, that which is to be found beneath the surface.

"This was not to be thought of when we were entirely dependent upon sunlight—but at present we have in the electric and magnesium lights means by which to picture even the most obscure places, and by means of which photography may wrest from the sea her secrets.

"The first endeavors to accomplish this object were made by 'Regnard.' In his work entitled 'La Vie dans les Eaux,' he gives a description of which the substance follows:

"In the first place the lens must be of a class by which objects both near and remote may be photographed. So-called sharp focusing in the ground glass is not necessary—but one must be able to photograph all objects, no matter at what distance from the objective. In using such a lens under water it must be borne in mind that light rays under water are not exactly in the same manner as in the atmosphere.

"An arrangement must be provided by which the lens can be uncapped and capped at a given instant, and the whole apparatus must be able to resist any injury from the pressure of water to which it is subjected. Regnard's apparatus, of which we give a view, consists of a copper cylinder closed above and below by copper plates; the upper plate rests upon a rubber ring, and can be screwed down securely. In this cylinder is a camera, C, with a sensitive plate—which can be exposed by means of a shutter.

"Below the cylinder is a tripod which upon lowering the apparatus rests upon the bottom. The objective which is in the lower end of the cylinder is thus always at a uniform distance from the bottom. Especial means must be taken to overcome the tendency of the apparatus to rise. The pressure of the water, even at a depth of 10 metres is about equivalent to that of the atmosphere.

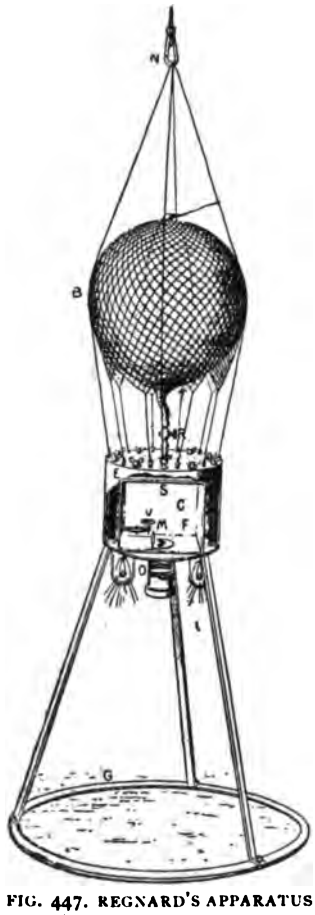


FIG. 447. REGNARD'S APPARATUS FOR SUBMARINE PHOTOGRAPHY.

"The pressure is overcome by means of a balloon, B, which is filled with air, and which is connected with the interior of the camera by a tube. When the cock, R, is open as the apparatus sinks, the balloon, B, is compressed and there is an equilibrium of the pressure within and without the camera. The shutter is opened and closed by means of clock work, the speed of which is regulated by means of a fan, V.

"The illumination is by electric light furnished by accumulators which are contained in a space around the cylinder. Two incandescent lamps stand on each side of the objective, and are provided with strong glass protectors. It is evident that the accumulators would soon be exhausted in case they were continuously employed. An arrangement is provided by which the current is turned on the moment the exposure is made. The light is thus used only during the exposure. The apparatus is lowered overboard by means of a cable."

Fig. 447 shows the apparatus. S is the plate, M the shutter, LL the electric lights operated, by means of an accumulator. Whether the apparatus produced good photographs is not known to the author, he never having seen the results.

Lately M. Bouton has succeeded in making photographs of the bottom of the sea, but he employed the magnesium light instead of electric. M. Bouton describes in *La Nature* the working of his apparatus:

"An ordinary photographic camera, whose lens has a fixed focus, is enclosed in a metal box in the form of a rectangular parallelopipedon. Transparent glass plates are arranged in front of the lens and over the finder."

Suitable means are provided by which the lens can be uncovered and the plate exposed; also the plates changed. A rubber balloon, filled with air and connected with the metal box containing the camera, serves to compensate for the water pressure as in the before described apparatus by Regnard. The whole rests upon a strong tripod provided with weights to make it more stable. When used in water too deep for sunlight to penetrate, artificial illumination is necessary. The latter is employed by Bouton in the following manner:

"An alcohol lamp, protected from the water, is placed on top of a receiver, of about 200 litres capacity, which is filled with oxygen. The lamp is protected by a bell glass, which is firmly secured to the receiver. Opposite the flame is a tube which is connected with a reservoir which is filled with magnesium, which can be blown through the flame in the usual manner. When the apparatus is submerged, a simple compression of the bulb is necessary to project the magnesium powder into the flame. Three grammes of magnesium may thus be burned. When operating near the shore at a depth of about one metre, no artificial light is necessary, and with an exposure of about ten minutes, good pictures may be obtained. For greater depths it is necessary for the operator to descend to the bottom in order to select the view, and to set the apparatus, so that he may be certain that he may secure what he desires to photograph."

FIG. 448.—SUBMARINE PHOTOGRAPHY. BOUTON'S METHOD.

When operating at a depth of six or seven metres, the exposure should be of thirty minutes' duration. In order to secure sharp pictures the author deems it necessary to employ a color screen in front of the objective, and good results were obtained only in still water. When operating by magnesium light, this condition is not altogether necessary, as Bouton obtained good pictures in rough weather. The accompanying cut shows the manner of making a submarine photograph by Bouton's method.

SUBSTRATUM.—An underlying layer.

SUBTERRANEOUS PHOTOGRAPHY.—The chief difficulty in underground photography lies, as would naturally be imagined, in the illumination. To do this satisfactorily by artificial means requires much care and thought. Mr. J. C. Burrow, writing of his experiences in photographing the workings of a Cornwall tin mine says: "After preliminary trials with cameras of various dimensions a half plate was chosen on account of its lightness, portability, and moderate size, the latter being specially important in confined situations. Double plate holders were employed, for, although there was no danger of light when the candles were extinguished, and plates could be safely changed, yet it was found impossible to keep the hands clean. A Zeiss Anastigmat, Series III., was used and gave beautiful results. A sliding tripod was also found very useful as the camera had often to be tilted at an angle of 60 degs., and the front leg tied to a rock to prevent overbalancing.

"It is needless to detail the incidents attending the transport of apparatus from surface to the bottom of an inclined shaft half a mile below. Some were unpleasant, others amusing.

"Readers intending to attempt underground photography must not be discouraged when staggering through the semi-darkness with a hydrogen cylinder under one arm and a pair of lime-light burners under the other, if they fall headlong into a pool of water by the side of the level. Nor must they lose their self-control when, after carefully selecting the driest spot available to open the magnesium powder tin for recharging the lamps, a 'flush' of water from some unknown source falls into the tin as soon as the cover is off, instantly dropping the

Photo by J. C. Burrow.

FIG. 449.—A SUBTERRANEAN PHOTOGRAPH.

curtain most effectually upon the remainder of the day's programme.

"The writer, after repeated unsatisfactory experiments with different flash lamps, designed a pair of triple flash arrangements, which have proved exceedingly satisfactory. The high temperatures of the deep mines caused camera and lens to be covered with condensed vapor for some time after the scene of operations was reached, a source of much bother.

"A state of readiness having been arrived at, the word to 'light up' produced a powerful flash from the lamps and ribbons simultaneously. The lime-lights were previously at their maximum intensity. An exposure of from two to four seconds generally gave the best results. If everything appeared favorable in the strong light, another subject was sought, for a second exposure in the same place on the same day rarely gave good results, owing to the 'fog' caused by the products of the combustion of the magnesium."

Photo by J.C. Burrow.

FIG. 450.—A SUBTERRANEAN PHOTOGRAPH.

SUGAR OF LEAD.—See **Lead Acetate.**

SULPHATE OF BARYTA.—See **Barium Sulphate.**

SULPHATE OF CALCIUM.—See **Calcium Sulphate.**

SULPHATE OF SILVER.—See **Silver Sulphate.**

SULPHIDE OF AMMONIUM.—See **Ammonium Sulphide.**

SULPHIDE OF ANTIMONY.—See **Antimony Sulphide.**

SULPHIDE OF POTASH.—See **Potassium Sulphide.**

SULPHITE OF SODIUM.—See **Sodium Sulphite.**

SULPHITES, TESTS FOR.—Sulphites in solution give a white precipitate with nitrate of silver and a blood-red color with ferric chloride.

SULPHOCARBONIC ACID.—See **Carbon Disulphide.**

SULPHOCYANATE OF AMMONIUM.—See **Ammonium Sulphocyanate.**

SULPHOCYANIDE OF AMMONIUM.—See **Ammonium Sulphocyanate.**

SULPHO-PYROGALLOL.—A name given to solutions of pyro with sulphite of soda as preservative.

SULPHUREA.—See **Thiosinamine.**

SULPHURETTED HYDROGEN (Formula, H_2S; synonym, *hydric sulphide*).—An inflammable gas having a very disagreeable smell. It is slightly soluble in water, and more so in ammonia, soda, and potash. It is principally employed in photography to precipitate silver sulphide from fixing baths containing alum.

SULPHURET OF AMMONIUM.—See **Ammonium Sulphide.**

SULPHURET OF CARBON.—See **Carbon Disulphide.**

SULPHURIC ACID(F ormulate, H_2SO_4; molecular weight, 98; synonym, *hydric sulphate*)—Pure sulphuric acid is prepared by distilling oil of vitriol, when the impurities are left behind and a colorless liquid is produced.

Nordhausen, or fuming sulphuric acid, is prepared by passing sulphuric acid vapor over red-hot bricks. It can be distinguished from English sulphuric acid by its fuming in the air when the bottle is open.

Sulphuric acid is a heavy, oily liquid, with a specific gravity of 1.845. Great care must be used in handling it, as it corrodes the skin, clothes, etc. It is miscible in all proportions with water, great heat being evolved; therefore, in adding it to water, this must be done in a vessel that will not easily break by the heat.

It is employed in photography in the manufacture of pyroxyline, and for a variety of other purposes.

TABLE OF STRENGTH OF SULPHURIC ACID AT 15 DEG. C.

Sp. gr.	Per cent. of H_2SO_4	Sp. gr.	Per cent. of H_2SO_4
1.845	100	1.306	40
1.825	90	1.223	30
1.736	80	1.144	20
1.615	70	1.106	15
1.501	60	1.068	10
1.399	50	1.032	5

Impure samples contain lead, but if this is present a milkiness is observed when diluted with water.

SULPHURIC ETHER —See **Ether.**

SULPHUROUS ACID (Formula, H_2SO_3; molecular weight, 82; synonym, *hydric sulphite*). —A colorless liquid prepared by deoxidizing sulphuric acid with charcoal. It has a pungent sulphurous odor, and should be used fresh, as it changes to sulphuric acid. Its fumes are very poisonous. It is employed in photography as a pyro preservative, and also as an addition to the fixing bath.

TABLE OF STRENGTH BY SPECIFIC GRAVITY.

Sp. gr. at 15 deg. C.	Percentage of Sulphurous Acid.	Sp. gr.	Per centage of Sulphurous Acid.
1.005	.95	1.027	6.68
1.009	1.90	1.031	7.63
1.013	2.86	1.036	8.59
1.016	3.82	1.046	9.54
1.020	4.77		
1.023	5.72		

SULPHUR TONING.—An old method of toning silver prints. They were immersed in an acidified solution of sodium hyposulphite. The sulphur is precipitated by the action of the acid, and clings to the image, giving it a brown tone. Prints toned in this manner, however, usually have yellow whites, and are far less permanent than if toned with gold or platinum.

SUPERSATURATED.—Saturated to excess.

SURFACING.—A method of giving a brilliant polish to positive prints. With a print the surface of which is composed of gelatine, as, for instance, a bromide or a gelatino-chloride print, but little trouble is necessary. All that is required is to thoroughly clean a glass plate, rub it over with a little French chalk or powdered talc, and squeegee the print face downwards upon it. When dry they will leave the glass with a very highly polished surface.

Instead of a glass plate, polished ebonite or enameled iron plates can be used.

With other prints, such as albumenized paper pictures, however, another operation is necessary. True, albumen prints can be surfaced in the same manner as the gelatine pictures, but the same high gloss is never obtained. It can, however, be given to them by first dipping the prints in a warm 10 per cent solution of gelatine, and then squeegeeing them to the glass plate. As, however, the glossy gelatine surface is easily affected by moisture, many operators prefer to coat the glass first with collodion, and then squeegee the gelatinized prints to this. A glossy collodion surface is thus obtained, less liable to become deteriorated by the influence of warmth and moisture.

SWEATING.—A whitish deposit which occurs on some kinds of glass. This defect is most often found with foreign makes of glass, and is considered to be due to the formation of a salt of lead. It can be detected by the tongue, and is least found with glass which has a greenish tint when viewed at through the edge turned towards the light.

SWING BACK.—A contrivance at the back of a camera which admits of an inclination of focusing screen, or dark slide, with reference to the axis of the lens. If the swing be confined to one plane it is a single swing back; if arranged to move upon both a horizontal and a vertical axis it is termed a double swing back. For the same purpose other devices have been used, such as a moving or swinging front, etc.

The swing back is useful in nearly all branches of photography. In landscape work it is

useful in bringing the foreground and distance into focus at the same time. To do this it is generally necessary to employ a very small stop, which means a considerably increased exposure. By moving the top part of the swing back in an outward direction, however, it is possible to bring both planes into focus. With a double swing back objects at any part of the plate, whether at the top bottom, or sides, can be brought into focus.

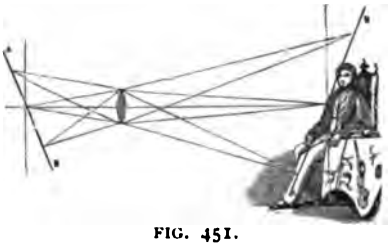


FIG. 451.

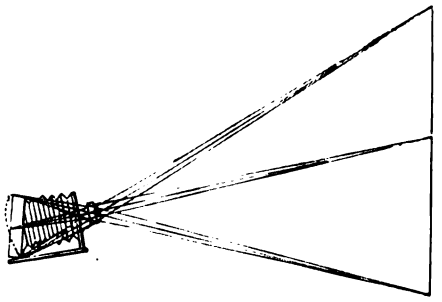


FIG. 452.

In architectural photography the swing back is exceedingly useful although often abused. When it becomes necessary to tilt the camera to take in a large building the vertical lines will naturally all converge to the top, causing the houses to have a tumbled down appearance. By means of the swing back, however, the back of the camera can be kept perfectly horizontal, and the lines will be straight

In portraiture the swing back is also useful in bringing all the parts of the sitter into focus, without increasing the exposure, by stopping the lens.

The theory of the swing back is this: The nearer an object from which rays of light proceed, is to the lens, the longer will be the focus of these rays after they have passed through the lens, consequently those rays which proceed from distant objects have a shorter focus than those proceeding from a nearer point. By swinging the back of the camera it will not be difficult to see how it is possible to get both rays in focus at the same time and upon the same plane.

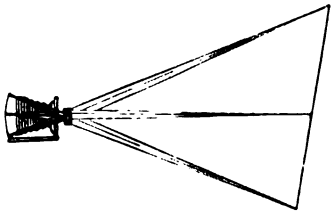


FIG. 453.

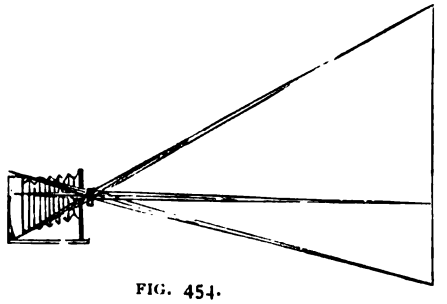


FIG. 454.

The simplest form of swing back is that in which the back of the camera is hinged to the baseboard. The most perfect form, however, is that in which the back, whether swung horizontally or vertically, makes its own center the center of movement. Figs. 451 to 454 show the various effects obtained by the use of the swing back. (See Burton's Photographic Optics, page 71.)

SWING FRONT.—A makeshift way of obtaining the same end as a swing back, which it does, though in a less perfect manner. The horizontal swing to the front is of little use except with a camera fitted with conical bellows. If the back and front are each provided with a horizontal swing, the difficulty is removed. The swing front *in addition to* the swing back, is often very useful.

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FIG. 455.—EFFECT OF TILTING THE CAMERA WITHOUT USE OF SWING BACK.

SYMBOLS, CHEMICAL.—See **Elements.**

SYMMETRICAL LENS.—A name given to a certain class of photographic lenses.

SYPHON.—A curved tube having one branch longer than another, used for transferring liquids from higher to lower levels. A convenient form of syphon can be made with a piece of indiarubber tubing bent in two, one length being longer than the other. The tube is then filled with the liquid, and the short end immersed in it, when the whole of the solution contained in the vessel can be transferred to another receptacle. It is a very useful instrument for removing

the liquid from a vessel without disturbing the precipitate at the bottom. A very delicate syphon for draining off the water very slowly from a precipitate can be made with a piece of soft wool, one end dipped in the solution and the other end (which must be the longer) left hanging over the side of the vessel. The wool must first be wetted to give a start.

TALBOTYPE PROCESS.—See **Calotype.**

TANNIC ACID (Formula, $C_{13}H_9O_7CO_2H$; synonym, *tannin*).—Extracted from gall nuts, ether being used at the same time to dissolve the coloring matter and gallic acid.

Tannic acid does not crystallize, but is left on evaporation in brownish-white shiny scales, soluble in water, but sparingly so in alcohol. Its chief uses in photography are in the dry collodion process, and for hardening gelatine prints and films.

TANNIN.—See **Tannic Acid.**

TANNING PRINTS.—Gelatino-chloride prints can be tanned or hardened with a dilute solution of tannic acid. It is, however, liable to cause the print to turn yellow after a little time. The best method of hardening is by means of a strong solution of chrome alum. The effect of this is to better ensure the prints leaving the glass in the glazing process, and also gives the gelatine a harder surface, less sensible to atmospheric influences. (See **Tannin Solution.**)

TANNIN PROCESS.—An old dry-collodion process invented by Major Russell. A glass plate is first well cleaned with Tripoli powder, and then washed in clean water and dried with a soft cloth previously warmed. One side of the plate is then coated with the following gelatine solution in the same manner as collodion:

GELATINE SOLUTION.

Nelson's gelatine	20 grains
Water	10 ounces
Spirits of wine	½ ounce

Dissolve the gelatine in the water and add the spirits of wine. The solution is then filtered through fine muslin or flannel.

After coating the plate with this the superfluous gelatine is poured back into the bottle, and the plate stood up on end on a piece of blotting paper, to drain and dry. When dry it is slightly warmed, and can then be packed away in a grooved box. A number of plates can thus be coated at one time, as, if they are carefully packed, they will keep any length of time. Care must be taken in coating that none of the gelatine solution gets on to the back of the plate. They are next coated with an old iodized collodion in the usual way, and then placed in a similar nitrate of silver bath to that used in the old wet-collodion process. In this bath the plate is allowed to remain for about five minutes, when it is taken out and well washed with plenty of water.

The tannin preservative bath is prepared as follows: To every ounce of distilled water required in the bath add 15 grains of tannin. Filter and pour out two separate portions of about four drachms each, one to be used for the first coating of the plate, which serves to remove the water remaining upon it after washing, and the second portion is then poured on and off the sensitized side of the plate. This operation is repeated several times, and the plate is then stood in a warm and dark room, resting upon blotting paper, and when dry it is ready for use in the camera. The time necessary for exposure usually varies between one minute on a favorable day to eight minutes in dull and dark weather.

The developing solution is made up as follows:

SOLUTION 1.

Pyrogallol	72 grains
Spirits of wine	1 ounce

To be preserved in a well-stoppered bottle.

SOLUTION 2.

Silver nitrate	20 grains
Citric acid	20 grains
Distilled water	1 ounce

Filter. For use, add half a drachm of No. 1 Solution to 3 ounces of distilled water, and then take about 3 drachms of this diluted pyro solution, and add to it from 10 to 15 minims of the silver nitrate and acid solution. Moisten the exposed plate with water, quickly and evenly applied, then pour on the developing solution, and let it flow gently to and fro over the plate. If the sky comes out quickly and strongly, but the details do not, it is a proof of under-exposure, which can sometimes be remedied by the addition of a little more pyro to the developer. If, however, the image appears to come out suddenly, the plate has no doubt been over-exposed; it is then neces-

sary to add a few drops of Solution No. 2 to the developer. After development the plate is fixed with sodium hyposulphite, well washed, dried, and varnished.

TANNIN SOLUTION.—A solution of tannic acid or tannin, as it is more commonly called, has been recommended for hardening gelatine prints and negatives. Gelatino-chloride prints, if treated with tannin, have a very hard surface, much less easily affected by moisture. In surfacing it also causes the prints to leave the glass more easily. The solution recommended is as follows:

Water	34 ounces
Tannin	15 grains
Salt	155 grains
Saturated solution of alum	3 fluid ounces

This is filtered or decanted as soon as all the ingredients have been dissolved. The prints are laid in it for a few minutes, and then well washed.

It should be stated that prints treated with tannin are liable to become yellow after a time.

Dr. Ehrmann recommends a tannin solution for the purpose of hardening the gelatine films of dry plates during hot weather, and thus prevent the frilling which so often occurs. This solution is used in place of alum, and is made up as follows:

Crystallized sodium sulphite	2 drachms
Tannin	32 grains
Water	16 ounces
Hydrochloric acid	1 drachm

It does not precipitate and cause the gelatine film to shrink up. The solution keeps well, and, owing to the presence of hydrochloric acid, any yellow color formed on the plate is entirely removed by bleaching, and the result is a clear printing solution.

TARTARIC ACID (Formula, $C_4H_6O_6$; molecular weight, 150).—Prepared from impure cream of tartar by precipitation with chalk and subsequent addition of sulphuric acid. It usually occurs as a fine white powder, or in prismatic crystals, soluble in water and alcohol. It is employed in photography in preserving sensitized paper, and collodio and gelatino printing-out emulsions containing free nitrate of silver.

TEA PROCESS.—An old dry-collodion emulsion process. A plate is first coated with a bromo iodized collodion and sensitized as usual, a preliminary edging having been given to it. After thoroughly washing, the plate is immersed in an infusion of tea, prepared by pouring about ten ounces of boiling water on half-an-ounce of good black tea. After standing one hour or two it is filtered, and is then ready for use. The exposure required is about three times that of wet plates, and development should be proceeded with within twenty-four hours of exposure.

Writing of this process Captain Abney says: "Of all dry processes the tea process is the most charming, when exposure can be given to the plates within two or days of preparation. They can be developed with an acid iron developer or by the alkaline developer. They possess a beauty not obtainable by most processes."

TELEPHOTOGRAPHIC LENS.—A specially constucted lens used in telephotography, *q.v.*

TELEPHOTOGRAPHY.—The combination of the telescope with the photographic camera. The simplest form of telephoto lens is the ordinary opera glass. Mr. O. G. Mason, in THE PHOTOGRAPHIC TIMES, describes a method of using this: He says: "An opera or field glass is a convenient and useful instrument in the kit of any touring photographer; and when he can easily and quickly attach it to his camera-box as an objective its great value is at once made apparent. Mr. Lawrence's method of doing this at little cost is a good illustration of Yankee ingenuity. It is not claimed that such a device will do all or as well as a telephotographic lens costing ten times as much; but it will do far more than most people could or would expect. Of course the field is quite limited, which, in fact, is the case with the most expensive telephotographic objective, and the sharpness of the image depends much upon the quality of the opera or field glass used. The accompanying views show the relative size and character of image by a forty-five dollar rapid rectilinear view lens and a four-dollar opera glass attached to the same camera and used at the same point.

FIG. 456.—CAMERA WITH OPERA GLASS ATTACHED.

The other illustrations show the camera as used and the method of opera glass attachment to the lens-board. It will be seen that the eye end of the opera glass is placed against the lens-board, one eye-piece in a slight depression around the hole through the center, and by a quarter turn the brace between the two barrels passes behind a projecting arm on a board, the focusing barrel resting in a slot in this arm, where it is firmly held in position by friction alone.

"As opera glasses are usually constructed for vision only, no attempt is made by the optician to make correction for securing coincidence of foci of the visual and chemical rays of light as in the well-made photographic objective. Hence, it is often found that the actinic focus falls within, or is shorter than, the visual. When this is the case, the proper allowance is easily made after a few trials".

Speaking of the telephotographic or large image lens, Dr. P. H Emerson, in his Naturalistic Photography, says: "This lens is constructed for photographing near objects of large size or distant objects of relatively large dimensions with comparatively short camera extensions. In all lenses that we have hitherto dealt with, the optical center of the combination has been contained within the lens mount. In the telephotographic lens now under consideration, the entire system is positive in nature, forming a real image; its constituents are ordinarily a positive lens of which the focus is considerably longer than that of the negative component. It is evident that if the components were placed in close proximity the focus of the system would be negative and hence no real image would be formed. By proper adjustment, however, of the separation between the two elements, a real image can be formed at any camera extension chosen. The shorter the extension the greater is the amount of subject (always a narrow angle) included upon the plate, and the greater the extension the less the amount included upon the same plate.

"The greater the camera extension the longer is the corresponding equivalent focus.

"This lens, therefore, has a great selective power, and is invaluable in composing pictures from its selective capability.

"This lens differs in optical construction from ordinary positive systems, in that the optical center, or to be more precise, the nodal point from which the equivalent focus is measured lies outside and beyond the front combination. The result of this is that the novice is astounded at the large size of image that can be obtained at a comparative short extension of camera.

"I am in the proud position, as it were, of being the godfather of this modern invention. In 1887 I asked Mr. Dallmeyer if such a lens could not be made, and he replied—no! Next in the autumn of '96, I again requested him to assist me in the construction of an instrument for the dual purpose of obtaining large images of small objects in natural history observations, as well as for photographing distances with truer rendering as regards perspective, and in a manner that should obviate the depressed and dwarfed rendering given by all ordinary photographic methods, and suggested that the ordinary tele-

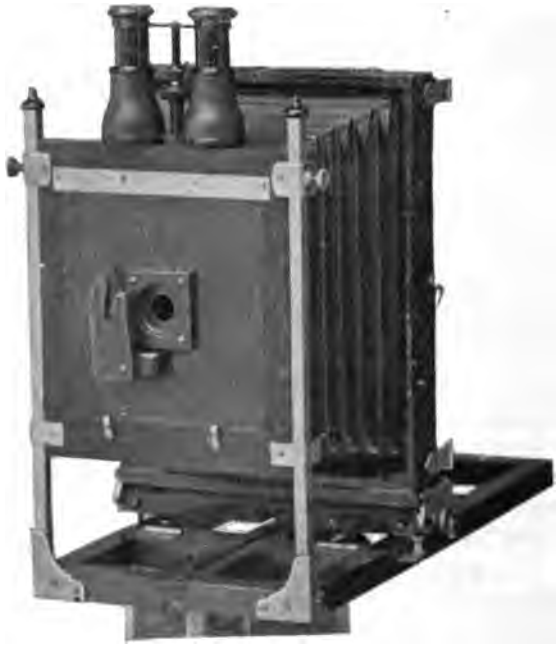


FIG. 457.—CAMERA SHOWING ARRANGEMENT FOR OPERA GLASS.

FIG. 458.—VIEW TAKEN WITH OPERA GLASS.

scope could be converted and arranged for such a purpose. This Mr. Dallmeyer very shortly accomplished, relying (as he has pointed out in a paper delivered before the Society of Arts) upon well known principles in the science of optics, and as the history of the subject has shown he was the first to do so in a serious manner for photographic purposes, and improvement after improvement has followed the first design. Needless to say many others seeing the commercial value of such a construction followed in the wake, but we wish to place on record the true history of the origin of this valuable adjunct to the apparatus of the photographic world.

"The original construction was of very great power or magnification, but Mr. Dallmeyer has subsequently introduced instruments of more moderate power. The high power systems include an angle 12 to 15 degrees; and the latter more moderate power from 18 to 20 degrees.

"Before giving shortly details of the method of calculating the focus and intensity ratios of the telephotographic system, we must call photographers' attention to two very important factors in the employment of this instrument.

"In the first place as we have already stated the optical center of the combination being outside and beyond the front combination, it will be evident that the slightest tremor in the camera itself will appear very much exaggerated in the resulting image as against using an ordinary camera, in which the optical center is contained within the lens itself, for in the telephotographic lens we have practically to consider any slight movement in the camera itself as a movement of the short end of a lever, the indistinctness of the image being reckoned by the vibration or movement of the long arm of the lever (in our case the optical center situated outside the camera).

FIG. 459.—VIEW TAKEN FROM SAME SPOT WITH AN ORDINARY VIEW LENS.

"The other point to be taken into consideration is one that can only be arrived at by practical experience, and that is the very short exposures necessary for distant objects. In ordinary photography we usually find without very careful development that the distance is "burnt out" if a full foreground development is required. No definite rule for reduction and exposure for distant objects can be set down, but if the exposure is calculated according to intensity ratios, we shall be safe in stating that a reduction of one half to a third of that calculated in the ordinary manner may be given.

"The simplest means for determining the corresponding foci and intensity ratios of a telephotographic system is by means of the ratio between the foci of the positive and negative elements. This ratio can always be determined; for example, if a six-inch lens is combined with a three-inch negative, the ratio is 2 to 1; if the six-inch positive is combined with a two-inch negative, the ratio is 3 to 1, and so on. If the distance between the diaphragm of the lens and the screen be measured and multiplied by the ratio as above stated, the result will be the equivalent focus of the system, and the intensity is simply this equivalent focus, divided by the clear aperture of the diaphragm employed. This rule is quite sufficiently accurate for all ordinary purposes, but we will add a further and exact mathematical rule, dependent upon the linear magnification of the image given by the positive lens alone.

FIG. 460.—TELEPHOTO LENS.

"*Magnification.*—Divide distance from negative or posterior lens (after the image has been focused sharply) to focusing screen by the focus of the negative lens, and add one to the result.

"*Corresponding focus.*—Focus of positive lens multiplied by the magnification.

"*Intensity ratio.*—Intensity of positive divided by the magnification."

TELEPHOTO LENS.—(See **Telephotography**).

TELESCOPIC PHOTOGRAPHY.—See **Astronomical Photography.**

TEMPERATURE.—The temperature of the atmosphere has undoubtedly an effect upon photographic operations. Intense cold opposes the formation of the latent image while intense heat will accelerate it. Every photographer is aware of the importance of keeping solutions at a fixed temperature. An ingenious arrangement for keeping developing solutions at a fixed temperature, devised by C. E. Hearson, is shown in Fig. 463.

The apparatus contains two 12 feet lengths of tubing (NN, OO), the water circulating through one tube (N) and the developer through the other (O, Fig. 463). The water is first passed through and received in the developing dish, which is thus warmed, the dish being then empty to receive the developer, both being at the same temperature. The thermostat (D) consists of two pieces of sheet copper soldered together at the edges; between the copper is placed a piece of blotting paper saturated with a liquid, which in this case boils at about 70 deg., so that so long as the liquid with which the paper is saturated is not hot enough to boil, the two sides of the copper capsule would lie quite close together, but when the critical temperature was reached, the sides would be distended, and a central rod (K) pushed up into the gas valve (H) and the height of the flame (B) thus adjusted.

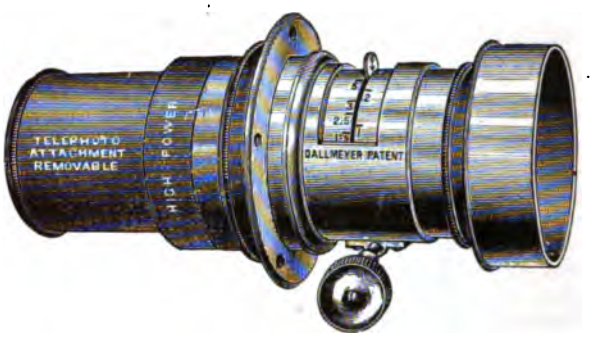


FIG. 461.—TELEPHOTO LENS.

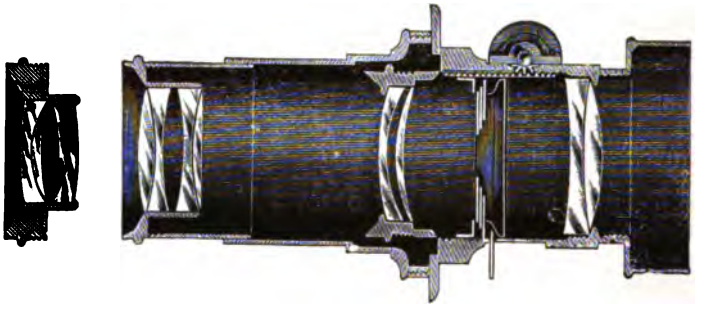


FIG. 462.—DIAGRAM OF TELEPHOTO LENS SHOWING ARRANGEMENT OF LENS.

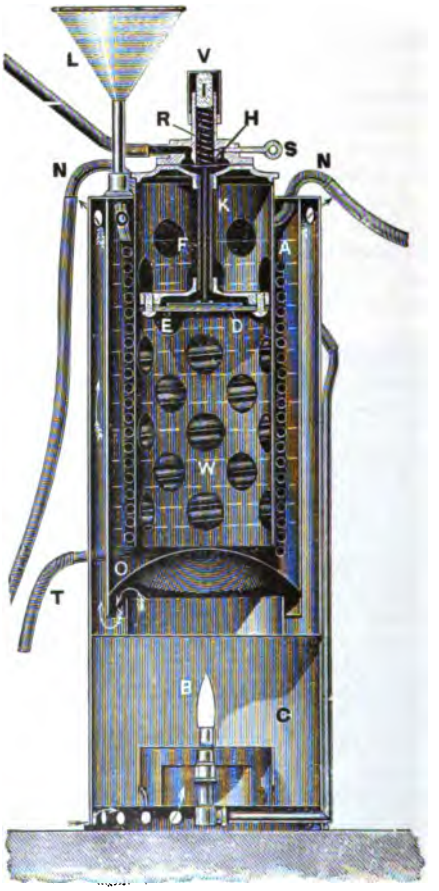


FIG. 463.—APPARATUS FOR KEEPING SOLUTIONS AT EVEN TEMPERATURE.

TEMPORARY DISHES.—Very handy temporary dishes can be made by bending a piece of stiff paper or cardboard all round and folding the corners so as to form a complete tray, useful for developing, etc. They can be made to last some time, and to resist the action of many chemicals if varnished with shellac or soaked in melted paraffin wax.

TENT.—In the old collodion days, when it was necessary to develop the plate immediately after exposure, a dark tent was an absolute necessity when working in the field. The advent of the dry plate has, however, changed this. Simple dark tents are, however, constructed for the convenience of tourists, enabling them to change and develop their plates when away from home. There are various designs, all having the same purpose, however.

TERCHLORIDE OF GOLD.—See **Gold Chloride.**

TESTING LENSES.—The lens being the most important part of the photographer's outfit it is advisable that this should be perfectly free from defects of all kinds. Lenses by well-known makers are invariably thoroughly tested before being sent out. With other kinds, however, some rough and ready means of testing it is useful. The lens should, if possible, be had on approval for a few days, and tested as follows :—

Spherical Aberration.—Fix a newspaper or something similar in front of the camera, pinning it quite flat all over. Then sharply focus the letters in the center, and then examine those at the sides. If blurred and indistinct, spherical aberration is present.

Chromatic Aberration.—Arrange three cards with letters on one behind and above the other, and focus for the

center. If on exposing the plate and developing, the center one does not come out the sharpest the lens is not properly corrected for chromatic aberration.

Flare.—Direct the camera to a strong light, and if a flare spot be present it will make its appearance on the focusing screen as a circular patch of light.

Curvilinear Distortion.—In the center of the screen focus any straight upright object, and then rotate the camera till its image is brought to the edges, when it should still be perfectly straight and upright.

Flatness of field can be detected by the same method by seeing if the image also remains perfectly sharp after the camera is rotated.

Centering of Combination.—To discover whether the combinations in a doublet lens are correctly mounted with regard to each other hold the lens at arm's length, and some distance from a single gas or candle flame. The reflected images of the flame should be one behind the other in a straight line. It is not, of course, possible to view them all when superimposed, but by a little manœuvring it can be seen whether they gradually come together as they should.

Focal Length.—Focus for a distant object, and then measure the distance from the diaphragm to the ground glass. This gives the focal length of the lens, and should not be less than the diagonal measurement of the largest size plate it is intended to cover.

Covering Power.—Place the lens in the camera and see that with the largest diaphragm it covers the plate well, even to the sides and corners.

Aperture.—A good lens should work with as large an aperture as possible. A "rapid rectilinear" should work at *f*/8, and a "landscape" at *f*/16.

The Glass.—Lenses are usually made of flint and crown glass. They should not have any perceptible color. This may be seen by laying the combinations on a piece of white paper. Bubbles and striæ can be detected by looking through the lens. The surfaces should be well polished and free from scratches.

The Mount.—The interior of the mount and the stops should be of a dead black without any reflecting parts.

TEST FOR CHEMICALS.—See **Photographic Chemicals.**

TEST PAPER.—Unsized paper prepared with certain substances and used for testing solutions for acidity or alkalinity.

Litmus Paper is made by steeping blotting paper into an infusion of commercial litmus. It takes a deep indigo color, and is used for testing acids. If a solution be acid it reddens it, or if exposed to acid fumes. It can also be used for testing alkalies by dipping into a dilute solution of sulphuric acid and drying it. It then takes a red color, which is changed to blue again on immersion in any alkaline solution.

Turmeric Paper is made by steeping blotting paper in an infusion of turmeric, which gives it a yellow color. This becomes changed to brown by the action of an alkali.

A good test paper for alkalies can, according to Sutton, be made by steeping blotting paper in a strong infusion of the petals of the red rose. The red color of this kind of paper is changed by an alkali to green.

Test papers are usually sold made up into little narrow books. They are of great use to photographers in testing the condition of the silver bath, and for a variety of similar purposes.

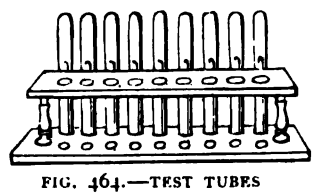


FIG. 464.—TEST TUBES

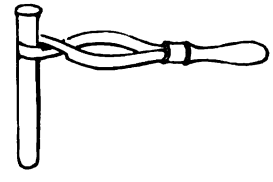


FIG. 465.—TEST TUBE HOLDER.

TEST TUBE.—A thin glass tube with a rounded bottom used in making tests. See fig. 464.

TEST TUBE-HOLDER.—An arrangement for holding one or more test tubes. See fig. 465.

THERMOMETER.—An instrument for measuring intensity of heat or temperature by means of expansion of a liquid or gas. Mercury is generally employed, and an ordinary thermometer consists of a spherical or cylindrical glass bulb at the end of a very fine tube, the bulb being completely filled, and the tube partly filled with mercury, while the space above the mercury contains only a small quantity of mercury vapor, which offers no resistance to the expansion of the mercury. When the temperature rises the mercury expands, and consequently rises in the tube. On the other hand, a fall in the temperature is indicated by a fall of the mercury in the tube. A graduated scale is attached with two fixed points, the freezing point and the upper or boiling point of water. The distance between the two fixed points is then divided into a number of degrees, which are continued above and below the two fixed points. In the Centigrade or Celsius thermometer, used by scientists all over the world, and in general use on the Continent, the distance between the two points is divided into a hundred degrees, the freezing point being o deg. and the boiling point 100 deg.

In the Reaumur scale the distance is divided into 80 deg., the freezing point being o deg., and the boiling point 80 deg.

On the Fahrenheit thermometer, which is the one most generally used in this country, the freezing point is marked 32 deg., and the boiling point 212 deg:, hence the zero of the scale on that part marked o deg. is 32 degrees below the freezing point, and the interval between the freezing and the boiling points consists of 180 degrees. The zero point is supposed to have been fixed by Fahrenheit at the point of greatest cold he had observed.

Degrees above o deg. are termed + degrees, and those below o deg. are termed — degrees.

The following formulæ will serve to convert any given number of degrees of one scale into the corresponding number of one of the other scales :—

C. + 5 × 9 + 32 = F.	F. — 32 + 9 × 5 = C.	C. + 5 × 4 R.
R. + 4 × 9 + 32 = F.	F. — 32 + 9 × 4 = R.	R. + 4 × 5 C.

For further convenience the following table of the assimilation of the three thermometers is appended :—

THERMOMETRIC TABLES.

SHOWING THE ASSIMILATION OF THE THERMOMETERS IN USE THROUGHOUT THE WORLD.

CELSIUS.	REAUMUR.	FAHRENHEIT	CELSIUS.	REAUMUR.	FAHRENHEIT	CELSIUS.	REAUMUR.	FAHRENHEIT	CELSIUS.	REAUMUR.	FAHRENHEIT
100	80·0	212·0	74	59·2	165 2	49	39·2	120·2	23	18·4	73·4
99	79·2	210·2	73	58·4	163·4	48	38·4	118·4	22	17·6	71·6
98	78·4	208·4	72	57·6	161·6	47	37·6	116·6	21	16·8	69·8
97	77·6	206·6	71	56·8	159·8	46	36·8	114·8	20	16·0	68·0
96	76·8	204·8	70	56·0	158·0	45	36·0	113·0	19	15·2	66·2
95	76·0	203·0	69	55·2	156·2	44	35·2	111·2	18	14·4	64·4
94	75·2	201·2	68	54·4	154·4	43	34·4	109·4	17	13·6	62·6
93	74·4	199·4	67	53·6	152·6	42	33·6	107·6	16	12·8	60·8
92	73·6	197·6	66	52·8	150·8	41	32·8	105·8	15	12·0	59·0
91	72·8	195·8	65	52·0	149·0	40	32·0	104·0	14	11·2	57·2
90	72·0	194·0	64	51·2	147·2	39	31·2	102·2	13	10·4	55·4
89	71·2	192·2	63	50·4	145·4	38	30·4	100·4	12	9·6	53·6
88	70·4	190·4	62	49·6	143·6	37	29·6	98·6	11	8·8	51·8
87	69·6	188·6	61	48·8	141·8	36	28·8	96·8	10	8·0	50·0
86	68·8	186·8	60	48·0	140·0	25	28·0	95·0	9	7·2	48·2
85	68·0	185·0	59	47·2	138·2	34	27·2	93·2	8	6·4	46·4
84	67·2	183·2	58	46·4	136·4	33	26·4	91·4	7	5·6	44·6
83	66·4	181·4	57	45·6	134·6	32	25·6	89·6	6	4·8	42·8
82	65·6	179·6	56	44·8	132·8	31	24·8	87·8	5	4·0	41·0
81	64·8	177·8	55	44·0	131·0	30	24·0	86·0	4	3·2	39·2
80	64·0	176·0	54	43·2	129·2	29	23·2	84·2	3	2·4	37·4
79	63·2	174·2	53	42·4	127·4	28	22·4	82·4	2	1·6	36·6
78	62·4	172·4	52	41·6	125·6	27	21 6	80 6	1	0·8	33·8
77	61·6	170·6	51	40·8	123·8	26	20·8	78·8	0	0·0	32·0
76	60·8	168·8	50	40·0	122·0	25	20·0	77·0			
75	60·0	167·0				24	19·2	75·2			
									FREEZING POINT OF WATER.		
									1	0·8	30·2
									2	1·6	33·8
									3	2·4	26·6
									4	3·2	24·8
									5	4·0	23·0

For extreme degrees of cold mercury cannot be employed, as it freezes at about 40 degs. below zero on the Fahrenheit scale. They can only be used for temperatures between — 40 degs. and + 675 degs., as it boils at the latter point. For lower temperature alcohol is used, as this has never been known to freeze, and for higher temperatures air thermometers are employed, in which changes of temperature are measured by the contraction of a known volume of air. Alcohol cannot be used for high temperatures, as it is soon converted into vapor. See fig. 466.

THIOCARBAMIDES REVERSAL WITH.—It has recently been discovered that the addition of a thiocarbamide to the developer will produce a reversal of the image. The following remarks upon the subject are by Professor Bothamley, F. I. C.*

* Photography Annual, 1894.

"Phenyl-thiocarbamide added in a small quantity to an eikonogen developer containing eikonogen 5 parts, sodium sulphite 10 parts, crystallized sodium carbonate 8 parts, water 400 parts, gives a reversed image with a normal and even with under-exposure. Over-exposure prevents reversal, and an excess of the thiocarbamide is also injurious, the best proportions being 12 to 15 parts of a saturated aqueous solution (1 : 1,000) to 100 parts of the developer. Potassium bromide in the proportion of 0·5 to one part of a 10 per cent solution in 100 parts of the developer aids reversal, and in some cases a small quantity of ammonia is beneficial. Good reversal is difficult to obtain with landscapes having strong contrasts, but for copying the results are more satisfactory. Before development the plate should be flooded with dilute nitric acid (5 per cent.), which is quickly washed off, and before fixing a short immersion in a two to three per cent. solution of cupric bromide gives clearer whites, but too long an immersion will weaken the lines. A bath of cupric bromide *before* development destroys the image. Potassium dichromate does not act so well as a nitric acid when used as a preliminary bath or added to the developer; potassium ferricyanide, when added to the developer acts as a powerful restrainer, and its clearing effect is not so good as that of nitric acid. Phenyl-thiocarbamide gives no similar reversal with ferrous oxalate, pyro, or quinol; with the first two it acts as a restrainer, and with the last as a powerful accelerator, giving general fog. Thiosinamine (allyl-thiocarbamide) acts less regularly but more energetically than phenyl-thiocarbamide, giving clearer whites. With eikonogen it gives the best results in presence of sulphite; with pyro containing sulphite it also gives reversal, but not with pyro in presence of much bromide; with Thomas's quinol developer it gave no reversal, but good results were obtained with a developer containing quinol, one part; sodium sulphite, two parts; crystallized sodium carbonate, 10 parts; water, 70 parts. With the eikonogen developer the addition of about two parts of a 10 per cent. solution of potassium dichromate to 500 parts of developer gives clearer results.

Thiocarbamide (sulpho-urea) itself also gives reversal with the eikonogen developer, but the results are very irregular. Neither thiocarbamide nor allyl-thiocarbamide gives good results for copying, even with the preliminary bath of nitric acid. Very few experiments with the spectrum were made, but it seems that the reversal of any particular part of the spectrum is almost entirely a question of the exposure. In some cases with phenyl-thiocarbamide and allyl-thiocarbamide the image first develops normally, but as development continues reversal takes place; in other cases the plate seems to fog all over, and the reversal is only evident after fixing.

All the thiocarbamides exert no reducing action on the haloid salts of silver in absence of an alkali, though thiocarbamide and allyl-thiocarbamide form pasty compounds with them. In presence of an alkali, partial reduction takes place even without exposure to light, and the reduction proceeds further on addition of eikonogen. Simple carbamide (urea) has a slight reducing action on precipitated silver bromide in presence of an alkali, but has no actioe on gelatino-bromide plates, and gives no reversal when added in any proportion to an eikonogen developer.

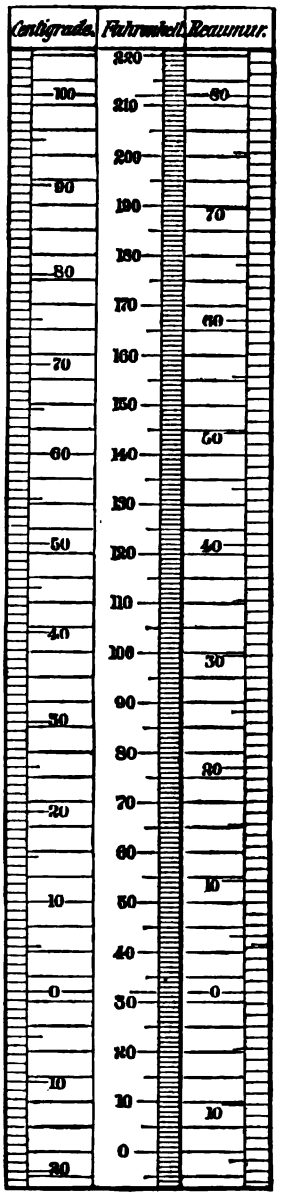


FIG. 466.—COMPARATIVE THERMOMETRIC SCALES.

No reversal takes place when any of these compounds is added to the hydroxylamine developer, though thiosinamine, like glucose seems to prevent the evolution of gas."

THIOSINAMINE (Formula $CS\,NH_2\,NHC_3\,H_5$, Synomyns *Sulphurea, Allyl-sulphurea.*—Colorless and odorless crystals easily soluble in water and alcohol. Liesegang, in 1883, pointed out the value of the substance as a fixing agent. It was, however, very expensive. Recently the price has been very much reduced. It is also valuable as a clearing agent for chloride emulsion papers and plates.

Dr. Bogisch pointed out that the brown stains especially resulting from the use of an organic developer—a pyro-developed one for instance—could be readily removed by immersion for ten minutes or so in a solution composed of a thousand parts of water, twenty of thiosinamine, and ten of citric acid.

It is also claimed that with this substance discolorations produced by the use of certain developers or old fixing solutions can be easily removed. In using the ferrous oxalate developer for bromide paper, it is well known that an acid clearing bath is necessary to prevent yellow dis-

colorations. A small quantity of thiosinamine and acid has this effect, with the additional advantage, it is said, of being a permanent one. The directions given for its use are as follows:

The negative or paper print (bromide or chloride silver plates and papers) are previously fixed with hypo, and after the hypo has been thoroughly removed by washing, the negative or paper print is put into *one of the following solutions* until the discoloration or stain has disappeared:

SOLUTION 1.

Sulphurea	300 grains
Citric acid	150 grains
Water	1 quart

SOLUTION 2.

Sulphurea	300 grains
Alum	300 grains
Acetic acid	150 grains
Water	1 quart

The pictures, after removal from the solution, are thoroughly washed. It is not advisable to immerse the pictures in the solution unless all fixing hypo has been removed, as the citric acid decomposes the hypo and would cause yellow stain. The above solutions may be used over and over again. Please note that sulphurea does not act in alkaline solution.

For fixing, the following solution is recommended:

Sulphurea	300 grains
Citric acid	75 grains
Water	1 quart

This solution can be used for silver chloride negatives, also for celloidin, gelatine and albumen positives, and such diapositives (lantern slides) which contain pure chloride of silver.

For fixing the positives, etc., after some have been toned in an acid bath (not containing fixing hypo), they are immersed for about ten minutes in the above solution, and then washed in a bath of water containing 15 grains citric acid to 1 quart of water. The addition of soda or potash to the solution is not permitted.

The solution is not applicable to fixing of silver bromide negatives, paper, or diapositives, which contain, besides chloride of silver, also bromide and iodide of silver.

THIOSINAMINE TONING.—According to Liardin (*Photographische Mittheilungen*) the following mixture may be used for a combined toning and fixing bath with good results for gelatino-chloride paper:

Water	100 parts
Thiosinamine	100 parts
Solution of chloride of gold (one per cent)	100 parts

The prints must remain in this bath about eight minutes. If the following chlorides are used, the various tones are obtained. Potassium chloride gives brown; salt, yellowish brown; cadmium chloride gives first orange, then gray green; aluminum chloride gives grayish brown, yellowish brown, and greenish gray tones; nickel chloride gives yellowish sepia; cupric chloride in fresh solution, yellowish green, when old, gray green; platinum chloride, gray brown; potassium chloro-platinite, brown; gold and potassium chloro platinite gives blackish violet; and aluminum and platinic chloride, brownish sepia.

THIOSULPHATE OF SODIUM.—See **Sodium Hyposulphite.**

TIME SHUTTER.—A shutter arranged so that exposures of any length can be given to the plate.

TINCAL.—See **Borax.**

TONING.—The process of changing the color of the silver print or other kind of positive from an unpleasant to an agreeable tone. The color of a silver print upon albumenized paper is usually of an offensive red, which it is very necessary to alter. The operation in toning usually consists in changing the color by partial substitution of gold, platinum, or some other metal for the silver of the print.

It is true that if a silver print be merely fixed in an acidified fixing bath of sodium hyposulphite, an agreeable brown tone will be obtained, for the reason that the sulphur precipitated by the action of the acid would adhere to the image, but this method of sulphur toning, although practiced in the earlier days, is now abandoned on account of the inferior permanency of the results.

The principal method of toning is by means of an alkaline solution of gold. Platinum is also finding much favor as a toning agent.

The accepted theory of the gold toning process is that the gold is deposited from an alka-

line solution of its terchloride in a layer over the reduced silver. Gold is very easily reduced from its salts to the metallic state. When, therefore, the silver image is immersed in the solution of chloride of gold, the silver having a great attraction for the chloride, the gold parts with it willingly, and it goes over to the silver to form silver chloride and the dark sub-chloride where the silver has been reduced by the light. Now the gold having parted with its companion, naturally falls down as a precipitate of metallic gold depositing itself upon the image. The color of the gold precipitated is regulated by the rapidity of its precipitation. A very slow precipitation gives fine particles of a reddish color, whereas quick precipitation gives coarser particles of a bluish color. The color of these particles gives the color of the image, consequently by regulating the precipitation we can get a variety of agreeable tones between the two extremes of red and blue. It will be obvious from this that the color of the image is no guide to the amount of gold in it. It is stated upon good authority that the greater the amount of gold contained in the print, the much greater the permanency of the image; it therefore follows that it is not a good plan to be too economical with the gold salt.

It should also be remarked that the variety of color differs very greatly with the kind of bath used with different brands of paper, and also to a certain extent with the quality of the negative.

The prints are prepared for the toning process by well washing in several changes of water to remove all soluble matter, except with toning baths containing chloride of lime and sulphocyanides, as these apparently require a free silver before any action will take place. Some operators prefer to place them after washing in a very weak solution of common salt—about a pinch to the pint. This gives the prints a redder color, and makes the color change in toning more obvious. A preliminary bath of sodium carbonate gives more purple tones; it is also very necessary with "preserved" ready-sensitized papers, which usually contain a large quantity of free acid, and which it is necessary to neutralize.

There are a very large variety of toning bath formulæ, many of which are given under **Toning Bath.**

After washing, the prints are placed one by one into the toning solution, which should be contained in a white porcelain dish used only for that purpose. The depth of the solution should be at least half-an-inch Too many prints should not be toned at once, as the operator should have complete control over each one. They should be kept constantly moving, and prevented from adhering to each other.

The temperature of the toning solution should be between about 65 deg. and 75 deg. Fahr., except with gelatine prints, when, of course, it must be colder, or the gelatine would perhaps dissolve. In toning the following should be noted: Hard intense prints require vigorous toning, and should be placed face downwards in the solution. Weak prints require gentle toning. Toning the prints with the face downwards hastens the operation; with the face upwards it retards it.

The greatest enemy of the toner is hyposulphite of soda. Every precaution must, therefore, be taken that this substance does not reach the toning bath, the toning and fixing operations being kept as separate as possible.

When the desired tone (as viewed by transmitted light) is arrived at, which should take at least ten minutes, the prints are removed. Practice only will enable the operator to know with certainty when to remove the prints from the gold bath, as this differs with the different solutions. With some the prints change to a considerable extent in the fixing bath. With regard to the correct illumination for the toning operation, some prefer to work in dull, diffused daylight, and others by gas or other artificial light. With the latter, of course, allowance has to be made for the different appearance of the color when viewed by daylight.

Upon removal from the toning bath the prints are laid in a dish of cold water. To prevent further toning by the action of the solution in the print, a little common salt should be added.

The failures most likely to be met with in the toning process are the following: If the prints tone too rapidly the bath is too strong in gold. Unevenness of tone will also arise from this defect. The prints will also lose a great deal of their tone in the fixing bath. Uneven toning is also the result of the bath being acid or too warm. If the prints are allowed to stick together or to the sides of the dish, patchy unevenness will also be caused, or if fresh gold solution be added while the prints are in the bath. If the prints tone too slowly it is possible that the solution is too weak in gold. Sometimes they will refuse to tone from this cause, or from the bath being contaminated with foreign impurities, or from its being too cold.

Loss of tone in fixing is an annoying defect, more often occurrent with some gold than with others, also with inferior samples of gold. This can sometimes be avoided by making the fixing bath acid with acetic acid, and then neutralizing with ammonia till distinctly alkaline to test paper. If not made alkaline, however, a yellowness of the whites will be caused. This latter defect may be caused by over-toning. See also **Platinum toning, Palladium toning. Osmium toning,** and **Iridium toning.**

TONING BATH.—A solution used for the purpose of changing the reduced silver of the image to an agreeable color which shall not be destroyed in the fixing bath. The following is a

fairly complete list of the toning baths in daily use at the present time. With the gold toning baths it is very convenient to dissolve the contents of a 15-grain tube of gold chloride in 15 drachms of water, neutralize it with a little common chalk, and for every grain recommended in the formula use so many drachms of the solution.

1.—Acetate Bath.

Sodium acetate	75 grains
Gold chloride	3 grains
Water	30 ounces

This is probably the most simple and generally used bath. It is exceedingly reliable, and gives uniform results. It works better after a few days than at first, and improves with age, being constantly replenished with a little of the stock solution. If required for immediate use hot water should be taken, and the bath used when cold. It gives with most papers brownish-purple tones. E. J. Wall prefers to keep a concentrated solution thus—

Gold chloride	15 grains
Sodium acetate	480 grains
Distilled water to make 7½ ounces.	

For use mix one half ounce, equal to one grain of gold to half-pint of water for every sheet toned. After use the bath can be filtered and used to dilute the next bath.

2.—Sodium Carbonate Bath.

Soda carbonate	45 grains
Gold chloride	3 grains
Water	30 ounces

A fresh solution of this bath must be made each time, about an hour before using, as it does not keep. The prints are made rather dark, and toned to a purple shade. After fixing, the image assumes a good brown color. If the temperature of the water be raised to about 180 deg, F., the carbonate and gold added, and the bath used in about ten to fifteen minutes, fine sepia tones are obtainable.

3.—Chloride of Lime Bath.

Chloride of lime	4 grains
Gold chloride	3 grains
Water	30 ounces

About a tablespoonful of chalk is added, to neutralize acidity. This bath can be used at once if made with hot water, or if with cold an hour or so should be allowed. It gives purplish-black tones. When it gets old, a little gold chloride and chloride of lime are added.

4.—Carbonate of Lime Bath.

Cold chloride	3 grains
Carbonate of lime	25 grains
Distilled water	20 ounces

The gold and chalk are thoroughly well mixed together in the water. After about an hour it is ready for use. Brownish-purple tones are obtained. The bath keeps fairly well.

5.—Bicarbonate Bath.

Gold chloride	1 grain
Sodium bicarbonate	4 grains
Water	8 ounces

or,

Gold chloride	3 grains
Soda bicarbonate	3 grains
Common salt	6 grains
Water	10 ounces

These baths are ready for use, but will not keep. They give warm brown tones.

6.—Phosphate Toning Bath.

Gold chloride	1 grain
Sodium phosphate	20 grains
Water	8 ounces

Should be used as soon after preparation as possible. It gives warm purple tones, but will not keep.

7.—Bicarbonate and Acetate Bath.

Gold chloride	3 grains
Soda bicarbonate	6 grains
Sodium acetate	72 grains
Distilled water	30 ounces

The gold and bicarbonate are added to two ounces of water, and well shaken until all color disappears. The acetate and remainder of the water are then added. Can be used in about six or eight hours after preparation.

8.—Acetate of Lime Bath.

Gold chloride	1 grain
Acetate of lime	20 grains
Chloride of lime	20 grains
Common chalk	25 grains
Tepid water	20 ounces

The gold is well shaken up with the chalk and a little of the water and then added to the solution containing other ingredients. This bath improves by keeping.

Another formula:

Acetate of Lime Bath.

A

Distilled water	500 c.c.
Chloride of gold	1 gramme

B

Distilled water	1500 c.c.
Acetate of lime	27.5 grammes

9.—Borax Bath.

Gold chloride	1 grain
Borax	1½ drachms
Boiling water	24 ounces

The borax is dissolved in the boiling water, and when cool the neutralized gold chloride is added. On no account add the borax to the gold. The bath should be prepared a few hours before using.

With regard to the keeping qualities of this bath much has been said both ways. The truth of the matter is that, although the borax solution will keep indefinitely, the gold becomes rapidly deposited; therefore, in using the bath again no saving of gold takes place, as enough is required as would be necessary for a new bath. There are many, however, who consider an old borax bath to tone better and evener than a freshly prepared one. If required to be used again it must be kept in a dark place.

10.—Borax and Tungstate Bath.

Gold chloride	1 grain
Borax	10 grains
Sodium tungstate	40 grains
Water	6 ounces

Very suitable for ready-sensitized paper.

11.—Acetate and Borax Bath.

Gold chloride	3 grains
Sodium acetate	30 grains
Borax	3 grains
Distilled water	30 ounces

Mix the gold and acetate in half the water and add the borax dissolved in the remainder. It can be used at once, keeps well, and gives brownish-black tones.

12.—Calcium Chloride Bath.

Gold chloride	15 grains
Water	5 ounces

Neutralize with lime-water, make up to fifteen ounces with water, and add two drachms of calcium chloride. This stock solution will keep for a long time for use. Dilute one ounce with ten ounces of water.

13.—Acetate Bicarbonate and Borax Bath.

Borax	330 grains
Sodium acetate	180 grains
Sodium bicarbonate	90 grains
Distilled water	20 ounces

This is the stock solution. For use, take 10 drachms and mix with 10 ounces of distilled water, containing 1 grain of chloride of gold. The bath should be made up about two hours before use. Old toning bath can be used instead of water for dilution. Rich brown tones can be obtained.

14.—Tungstate Bath.

Gold chloride	15 grains
Sodium tungstate	300 grains
Boiling distilled water	15 ounces

When cool it can be used, and it gives fine purplish-brown tones.

15.—Citrate Toning Bath.

Gold chloride	1 grain
Sodium carbonate	60 grains
Citric acid	20 grains
Distilled water	10 ounces

After mixing, the solution is warmed till it changes color. It is then used, as it will not keep.

16.—Sel d'Or Bath.

Gold chloride	1 grain
Sodium hyposulphite	4 grains
Hydrochloric acid	4 drops
Distilled water	10 ounces

The gold is dissolved in half the quantity of water, and added to the hypo dissolved in the other half, stirred constantly, then add the acid. The prints after toning are immersed in a soda bath, and then fixed.

17.—Sulphocyanide Toning Bath.

Gold chloride	1 grain
Potassium sulphocyanide	12 grains
Sodium hydosulphite	½ grain
Distilled water	4 ounces

Print rather deeply, and immerse in the toning bath without previous washing. Fix in fresh hypo.

Calcium Acetate Bath.

A

Water	500 parts
Gold chloride	1 part

B

Water	1500 parts
Calcium acetate	28 parts

Restrained Lime Bath.

Gold chloride	4 grains
Lime chloride	4 grains
Sodium chloride	4 grains
Distilled water	20 ounces

Gives black tones.

Bromide Bath.

Gold chloride	2 grains
Sodium carbonate	30 grains
Sodium bromide	1 grain
Distilled water	20 ounces

This bath should be used as soon after mixing as possible. It does not keep. Brown or chocolate-brown tones.

Toning Bath for Yellow and Faded Prints.*

Solution 1.

Distilled water	17 ounces
Sodium tungstate	154 grains

Solution 2.

Carbonate of lime	60 grains
Lime chloride	15 grains
Gold chloride	60 grains
Distilled water	15 ounces

* By M. Zaudaurek, of Vienna.

Solution 2 is made up in a yellow glass bottle, thoroughly well shaken up, allowed to stand for a day, and then filtered into another yellow bottle and kept tightly stoppered. After the prints have been well washed they are placed separately in the toning solution, made up of

Solution 1	5 ounces.
Solution 2	75 to 150 minims.

They should tone in about ten minutes, if quicker than this the proportion of solution 2 should be reduced. After toning, the prints are washed and fixed in

Solution 1	10 ounces.
Sodium hyposulphite	250 grains.

In this they should remain until the yellow color of the paper has completely disappeared. If very far gone this may take several hours. Afterwards well wash.

So far we have only considered toning solutions with gold for albumenized paper prints. Other metals, are, however, sometimes, used, as the following will show:

1.—Platinum Toning Bath.

Platinum perchloride	15 grains
Sodium bicarbonate	15 grains
Distilled water	15 ounces.

Print to a considerable depth, and just previous to toning add one drop of nitric acid for every grain of platinum used.

2.—Platinum Toning Bath.

Platinum perchloride	1 grain
Water	16 ounces
Potassium carbonate to neutralize	
Formic acid	½ to 1 drachm

A serviceable bath for silver prints upon plain paper; it gives deep black tones.

Platinum can also be substituted for gold in any of the gold toning formulæ, or a mixture of the two metals can be employed.

Platinum Toning and Fixing Bath.

A

Distilled water	10 c. c.
Platinic chloride	1.5 grammes

B

Distilled water	900 c. c.
Sodium acetate cryst.	30 grammes
Sodium hyposulphite	150 grammes

The prints are washed and toned in a mixture of 10 parts of A to 90 parts of B.

Uranium Toning Bath.

Uranium nitrate	1 grain
Gold chloride	1 grain
Sodium bicarbonate	20 grains
Distilled water	10 ounces

This bath must be made alkaline, and used immediately. Very fine purplish black tones are obtainable. Place the prints in salt and water both before and after toning.

Another bath is the following:

Gold chloride	4 grains
Uranium nitrate	4 grains
Sodium chloride	60 grains
Sodium acetate	60 grains
Distilled water	32 ounces

Neutralize the gold and uranium, previously dissolved in a little water, with sufficient sodium bicarbonate. Print deeply, and well wash previous to toning. Fix in

Sodium hyposulphite	2 ounces
Sodium chloride	1 ounce
Sodium bicarbonate	¼ ounce
Water	1 pint

Iron, Gold and Uranium Bath.

Gold chloride	1 grain
Uranium nitrate	1 grain
Sodium carbonate to neutralize acetate of iron solution	1 drop
Distilled water	8 ounces

For rich black tones; should be used as soon as the black precipitate at first formed, is dissolved.

GOLD AND LEAD BATH.

Lead nitrate	60 grains
Sodium chloride	80 grains
Sodium hyposulphite	1 ounce
Gold chloride	2 grains
Distilled water	20 ounces

Gives black tones. The water in which the ingredients are mixed should be warmed slightly. Fresh hyposulphite should be used for fixing.

COPPER AND GOLD BATH.

Sodium phosphate	80 grains
Cupric chloride	1 grain
Gold chloride	5 grains
Water	40 ounces

The gold should be neutralized with chalk.

Another formula is

Sulphate of copper	1 grain
Gold chloride	1 grain
Distilled water	10 ounces

The prints are allowed to remain in this solution for about five minutes, and are then transferred to

Gold chloride	1 grain
Sodium acetate	10 grains
Sodium bicarbonate	10 grains
Potassium chloride	2½ grains
Distilled water	10 ounces

The paper is preferably fumed with ammonia, and printed very dark. Purplish black tones are obtained.

OSMIUM TONING BATH.

Osmium ammonium chloride	23 grains
Osmiate of potash	1½ grains
Acetic acid	½ ounce
Water	36 ounces

This formula has been often recommended, but is rarely used, owing to the high price of the osmium salt.

PALLADIUM TONING BATH.

Palladous chloride	1 gramme
Chloride of sodium	1 gramme
Distilled water	100 c. c.

When these are dissolved, add 10 c. c. acetic acid and 400 c. c. of distilled water.

PALLADIUM TONING BATH.

Palladium chloride	1 grain
Sodium sulphite	20 grains
Water	10 ounces

Plain paper silver prints are brushed over with this solution until toned. They are then fixed in hypo containing a few drops of ammonia.

IRIDIUM TONING BATH.

Tartrate of sodium	0.15 gramme
Iridium chloride	1.50 gramme
Water (distilled)	100 c. c.

Boil for two minutes, then add 400 c. c. of distilled water and 10 c. c. of acetic acid.

MERCURY BATH.

Mercury chloride	2 grains
Tartaric acid	10 grains
Hydrochloric acid	5 drops
Distilled water	10 ounces

For black tones. Permanency of results very doubtful.

To simplify the toning and fixing operations combined baths have been recommended.

COMBINED TONING AND FIXING BATH.

Water	32 ounces
Sodium hyposulphite	8 ounces
Ammonium sulpho cyanide	1 ounce
Sodium Acetate	½ ounce

Mixed well and add

Water	8 ounces
Gold chloride	15 grains
Ammonium chloride	30 grains

Add to solution 100 grains of silver chloride, or some scraps of untoned paper, spoilt prints, etc.

For toning Alpha paper, developed with ferrous oxalate, the following combined toning bath is recommended :

Water	10 ounces
Sodium hyposulphite	2½ ounces
Sodium acetate	½ ounce
Ammonium sulphocyanide	¼ ounce
Gold chloride	4 grains

A very great variety of tones can be obtained, these being principally dependent upon the amount of exposure given to the print previous to developing.

For toning ferro-prussiate papers to a sepia tone, immerse in a dilute solution of potassium hydrate until they turn an orange color. They are then washed in water and immersed in a solution of tannin five grains to the ounce until of a dark brown color. Again wash in water and return to the potash solution until the desired tone is arrived at. Brown tones are obtained by omitting the last bath. Blacker tones can be produced by immersing in a three per cent. solution of sodium carbonate after treating with the tannin, then washing and returning to the tannin solution. Another method of obtaining black tones with this paper is by immersing the print in a ten per cent. solution of silver nitrate until the image disappears entirely. It is then washed for a couple of hours or so and developed with a ferrous-oxalate developer.

See also **Platinum Toning, Gelatino-citro Chloride Paper, Palladium Toning,** etc.

TORSION BALANCE.—See **Balance.**

TRACING PAPER.—A tissue paper of even body treated with oil, resin or varnish to render it transparent.

It can be made by dipping paper in a mixture of equal parts of Canada balsam and camphene and drying.

A German process consists in saturating the paper, preferably writing paper, with benzine, and before this evaporates applying a varnish as follows :—Boiled bleached linseed oil, 20 parts; lead shavings, 1 ; oxide of zinc, 1 ; Venice turpentine, ½. Mix and boil eight hours ; when cool strain and add white gum copal, 5 ; gum sandarac, ½. This varnish may be applied by dipping, or with a brush or sponge.

TRACINGS, COPYING.—There are a great variety of processes for copying tracings, a number of which are given here. Most of these processes give a negative image from an ordinary tracing. The two following methods will, however, be found useful, by which tracings may be reversed into negatives, so as to give positive images. The first is by Liesegang, and the second was published some time ago in the *American Machinist.*

First Method.—The tracing is made on paper with lithographic or autographic ink. Great care must be taken that the drawing pen does not cut through the paper.

When the tracing is dry it is stretched upon a drawing board in the usual manner. Under the tracing a sheet of blotting paper is placed. The drawing is then coated once or twice with a concentrated solution of aniline brown, by means of a wide, soft flat brush. After drying, the drawing is treated with a tuft of cotton or a sponge dipped in oil of turpentine, and rubbed over until all the lines appear in a clear white upon dark ground.

Second Method.—The drawing is traced on paper with a solution of citrate of iron and ammonia. When dry the surface of the sheet is blackened by means of a crayon, soft pencil or plumbago powder. The sheet is then immersed in water in order to dissolve out the ferric salt, which leaves the lines white. When all are quite clear it is dried.

TRAGACANTH.—See **Gum Tragacanth.**

TRANSFERROTYPE.—A process of transferring bromide prints to any suitable support, The paper is first coated with a soluble film of gelatine, and afterwards with an insoluble gelatine

emulsion, as used for bromide or chloride positive printing. The method of exposing, developing, clearing, fixing, etc., are the same as with the latter paper.

After the print is washed, and while still wet, it is laid face downwards upon the object to which it is desired to transfer the image. The surface may be polished or ground glass, porcelain, wood, ivory, or any substance that will stand the action of hot water, and allow the image to adhere. It must be perfectly clean, and free from grease and oil. Squeegee the wet print carefully in contact with the surface and place it under a blotter and weight to dry. When dry, pour hot water upon the back of the picture until the paper blisters, then run a pin under one corner of the paper and pull it gently away. After removing the paper gently rub the surface of the picture with a tuft of cotton, moisten with warm water, and set away out of reach of dust to dry.

The paper may be stripped any time after it has been thirty minutes under the blotter, but it is safer to allow it to thoroughly dry. The proper temperature of the hot water depends upon whether the paper is dry or not. If dry it should be between 160 deg. and 180 deg. Fahr. If only thirty minutes have elapsed after squeegeeing down, the water should be about 110 deg. Fahr., and the temperature gradually increased by the addition of boiling water until the paper blisters. Thirty minutes is the least time that should be allowed for drying, otherwise there is danger of the picture leaving the support.

Clean dishes and clean hands are essential in the production of clean work. The faintest trace of hyposulphite of soda or pyrogallic acid is fatal to good results.

TRANSFERROTYPE, TONING.—Warm tones, ranging from a rich brown to a brilliant red, may be obtained with transferrotype paper, after fixing and transferring (the image will not transfer after toning) by the following method :—

Two solutions are prepared.

SOLUTION A.

Potassium ferricyanide	100 grains
Water	24 ounces

SOLUTION B.

Uranium nitrate	100 grains
Water	24 ounces

These solutions keep separately, but must be mixed only for immediate use. Take equal parts of A and B, and immerse the image in it until the desired tone is obained, then wash thoroughly, and then immerse for five minutes in a fresh fixing-bath of

Hypo	3 ounces
Water	16 ounces

and wash thoroughly.

TRANSFERS.—There are several photographic processes by means of which images can be transferred to almost any support, as wood, glass, china, etc. The one most generally adopted is no doubt the single or double transfer carbon process. Liesegang introduced a very simple method of transferring prints. He coated thickly-gummed paper with a collodion printing-out emulsion. After printing upon this paper it was laid upon the final support, previously coated with a gelatine solution, and then melted. The gum substratum dissolved and the paper came away, leaving the image upon the support, which was then toned and fixed.

Another method is as follows: A sheet of paper is first coated with a gelatine solution, and this is damped and laid on to a sheet of glass. Little larger strips of paper are then pasted all round, half on the paper and half on the glass. When dry the expansion of the paper stretches it quite firm and flat. It is then coated with a solution of collodion containing about 2 per cent. of pyroxyline and 2 per cent. of castor oil. The paper can now be leveled and coated with a collodio-chloride or a gelatino-chloride printing-out emulsion, or an ordinary bromide or chloride emulsion as used for plates, and the image printed by contact and development. If a gelatine emulsion be used it must be made to contain as much alum as permissible to render the film insoluble. To transfer it is only necessary to coat the support with a 10 per cent. solution of gelatine, and after toning and fixing the print to squeegee it on to it. By the application of a little warm water the paper support, with the underlying film of gelatine, can be washed away. (See also **Transferrotype.**

TRANSLUCENT.—Substances are said to be translucent when they allow rays of light to pass through, but so nearly opaque that objects are scarcely, if at all, visible through them.

Paper can be made translucent by several different methods. In working with paper negatives it is almost a necessity to have the paper as translucent as possible to lessen the time required in making positives, and also for the purpose of removing as far as possible the grain or texture of the paper. Of the best known methods may be mentioned the following:

Prepare—

Castor oil	5 parts
Ether	1 part

Place the paper negative face downwards upon a piece of glass and spread this solution thickly over it, then well warm it till the oil has thoroughly soaked through the paper, and when cool remove the superfluous oil and again warm. Should any of the oil get on to the surface it can be readily removed with a little ether.

Another method is by means of an indiarubber solution composed of

Indiarubber solution	2 parts
Canada balsam	2 parts
Benzole	3 parts

This is rubbed well into the back of the negative with a piece of cotton wool till thoroughly soaked. It is then dried.

Passing through melted paraffine wax is also recommended for making paper translucent. This must be effected at a temperature so low as to enable it to thoroughly penetrate the paper. It is better not to iron the negative, but to simply warm it, and with a piece of soft cloth to remove all the superfluous wax. Paraffine cools instantaneously, and does not soil the albumenized paper. It renders the paper perfectly free from granularity and prints out rapidly.

A process by no means easy, but which may be made successful, is the following:

Make a mixture of

Gum dammar	20 parts
Gum elemi	5 parts
Benzole	100 parts

Pour this into a flat dish and place the negatives in one after another, and allow them to remain in it for about five minutes, and hang up to dry. Benzole must be occasionally added to the solution in consequence of its speedy evaporation. The negatives treated with this will be found very transparent and require no varnishing.

A common method of rendering paper negatives transparent is by means of vaseline. Although a special vaseline oil has been prepared for this purpose, the ordinary substance used as a pomade will answer very well. One method of applying it is to rub the vaseline thickly over the back of the negative, and then hold it near a fire so that the oil will melt and run well into the fibers of the paper. One of the drawbacks to the use of vaseline for this purpose is the necessity of always keeping the negatives treated with it between sheets of oiled paper to preserve the vaseline from evaporating when not in use for printing from.

It should be noted that before rendering a paper negative translucent it is always advisable to make a print, as with many negatives a better positive is obtained without oiling.

TRANSPARENCY.—In art, a picture painted or photographed on transparent or semi-transparent material, such as glass, thin paper, etc., to be viewed by the natural or artificial light shining through it.

Under this heading we will give the different processes of obtaining transparencies from an ordinary negative for various purposes, such as for window transparencies, lantern slides, stereoscopic slides, and also for making fresh negatives from a negative by first making a positive transparency.

There are a very great variety of methods, the simplest being, of course, the simple exposure of an ordinary dry plate behind a negative, and development, usually with hydrokinone, eikonogen, or other method which gives a more artistic tone than the useful pyro.

A good developer, giving pleasing black tones, is the following, recommended for "Paget. Prize" plates by the manufacturers, these plates being very suitable for transparencies :—

No 1.

Hydrokinone	1 ounce
Methylated spirit	10 ounces
Sulphurous acid	½ ounce
Potassium bromide	½ ounce

Dissolve the hydrokinone in the spirit, and add the acid. In another vessel dissolve the potassium bromide in 3 ounces of distilled water. Mix the two solutions, and make up to 20 ounces with distilled water.

No. 2.

Caustic soda (in sticks)	1 ounce
Sodium sulphite	5 ounces
Distilled water to make	20 ounces

One part of each of these two solutions to four parts of water. If too hard, more water should be added.

In the making of lantern slides or transparencies upon ordinary gelatino-bromide plates, the chief drawbacks are in the production of clear lights and brilliancy. A brand of plates should be chosen possessing a fairly thick coating. Authorities differ on the advisability of adding a little chloride to the emulsion for the purpose of improving the color. Others again recommend iodide for warm tones.

With a variety of developers a number of different effects can be produced, and colors of all kinds and shades to suit the taste of the worker can be obtained. The ferrous oxalate developer is one that is very generally used, and gives very good cold black tones. After developing, fixing and well washing, Pringle recommends a clearing solution composed of a very strong and saturated solution in water of alum and citric acid, to each pint of which about two drachms of hydrochloric acid are added.

FIG. 467.—CAMERA FOR MAKING LANTERN SLIDES.

Mr. F. C. Beach recommends the following eikonogen developer as a suitable one for lantern slide transparencies, giving a bluish black tone similar to the palladium or platinum tone usually given to wet-plate slides. The proportions are—

Sulphite of soda	10 grains
Eikonogen	5 grains
Carbonate of potash	2 grains
Water	1 ounce

This developer made up as recommended above will develop from seven to ten slides in succession. The rapidity of its action can, if desired, be retarded by adding a few drops of a ten grains to the ounce solution of potassium bromide.

Another method of making transparencies, or lantern slides, is by means of Alpha plates. These plates are placed upon the market ready for use, one of their peculiarities being the extraordinary latitude of exposure. Thus, from one negative, a number of perfect slides can be obtained with different exposures of from one to three minutes, all possessing the same depth, but differing in the color in the following order—greenish black, olive green, cold brown, brown, reddish brown, red, yellowish red. It will thus be apparent that it is possible to so arrange the exposure as to get the color most desired or the one most suitable to the subject. Besides the colors already stated, a further variety can be obtained by toning with the formula used in the combined fixing and toning bath recommended for use with the Alpha paper.

Water	10 ounces
Hypo	2½ ounces (Avoirdupois)
Acetate of soda	½ ounce (Avoirdupois)
Ammonium sulphocyanide	½ ounce (Avoirdupois)
Gold chloride	4 grains

This is used instead of the ordinary fixing bath, and the slide can be toned any time after fixing, The brown developed slides give the greatest range of tone in the toning bath.

A most beautiful process for the production of transparencies is the albumen process, although the difficulty of working it has prevented its use from being more universal. A description of the process will be found in another place. (See **Albumen Process.**)

Transparencies can also be produced by means of printing-out emulsions. A formula is given under the heading treating of gelatino-citro-chloride printing processes. Instead of spreading this emulsion upon a paper support, glass can be coated with it, and transparencies produced. Of course, the printing must be carried very far to get any degree of density when viewed by transmitted light.

Other methods of producing transparencies are by means of the carbon process, the collodio-chloride process, etc., all of which will be found treated upon in their various places.

TRANSPARENT CEMENT.—Made by dissolving seventy-five parts of caoutchouc in sixty parts of chloroform and adding fifteen parts of mastic.

TRANSPARENT PAPER.—Paper can be made transparent for copying drawings, plans etc., by lightly rubbing it with a ball of cotton wool saturated with pure benzine. The tracing can be made, and the benzine on evaporating leaves the paper quite opaque as before, and free from odor. For the best results, however, pure benzine should be employed.

TRAY COVER.—A cover of any suitable material placed over the developing tray when treating the latent image with the developer will serve as an extra precaution against the fogging of the plate by means of a too-actinic light, or by daylight entering the dark room.

TRICHLORIDE OF GOLD.—See **Gold Chloride.**

TRIHYDROXYBENZINE.—See **Pyrogallic Acid.**

TRIMETHYLAMINE (Formula $(C H_3)_3 N$).—A volatile liquid having a briny smell. It is sometimes employed mixed with pyrogallol in alkaline development.

TRIMMER.—A little instrument consisting of a sharp-edged wheel, fitted to a convenient handle, and used for trimming prints. One of the advantages this has over the trimming knife is the ability to cut the prints either when wet or when dry. There are two forms—the rigid used for cutting prints, and another form in which the cutting wheel turns upon a swivel, and with this instrument ovals or any similar shapes can be cut.

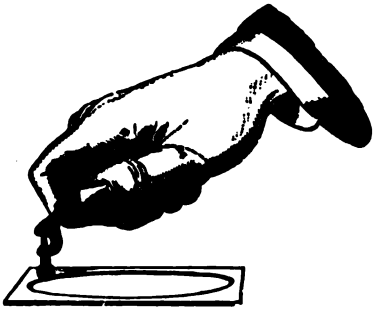


FIG. 468.—TRIMMER.

FIG. 469.—ACME PRINT TRIMMER.

TRIMMING.—The art of trimming or cutting the prints to the required size, simple as it may seem, is one that to do correctly requires no little practice. The principal requirements in a trimmed print are perfectly clean cut and parallel edges. Few things look worse than a badly trimmed print. This is especially noticeable with views of buildings or other objects having straight lines. If the prints be not trimmed with their edges parallel to these lines, the beauty of the print, if it be a good one, is entirely lost, as the houses will appear to be toppling over. In seascapes, too, how necessary it is that the edges should be trimmed parallel, and at right angles to the horizon line. It is a common, but nevertheless a bad, practice to trim the print all round parallel with the negative, but an artist would reduce his picture to any size and shape which he considered would give the best effect. This, in the majority of cases, would be very different from the standard sizes.

TRIPOD.—A three-legged stand for the camera when used for out-door work. The head is usually a solid piece of wood on a metal frame, upon which the baseboard should

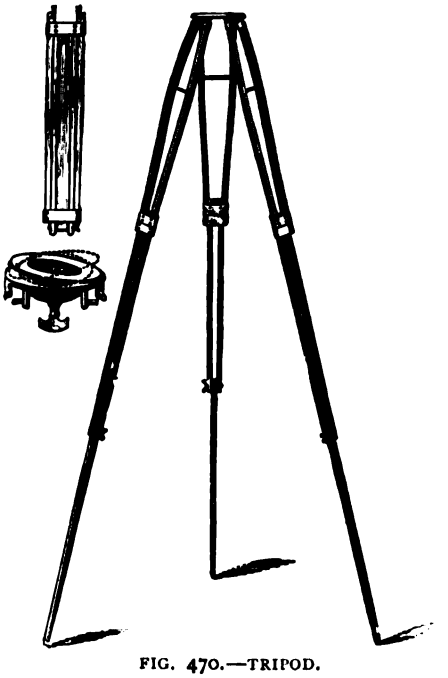


FIG. 470.—TRIPOD.

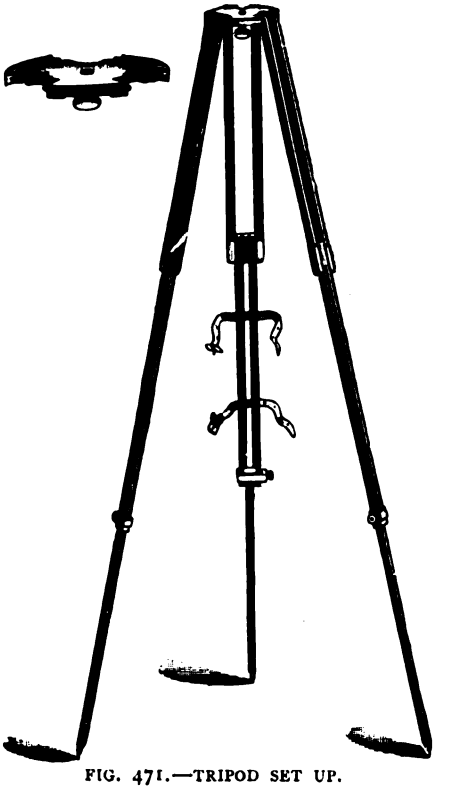


FIG. 471.—TRIPOD SET UP.

rest evenly all over its surface. This is an important point, as if the baseboard only touches a portion, or if the tripod head be too small, the camera will not be held firm, no matter how rigid the stand may be, and will vibrate at the merest touch. The tripod head is usually screwed centrally to the baseboard, but in the arrangement termed the "contained tripod head" the baseboard is fitted with a circular plate, bearing pins or holes to which the legs are attached. The advantage of this contrivance is that there is no loose screw to get lost, no tripod head to carry, and the camera is much more easily set up. The legs of the tripod stand are of very varied construction. The simplest consists merely of a stout ash pole composed of three portions, which spread out and form the stand. The length of this being usually about five feet makes it very inconvenient for travelling, however. For this reason tripods have been constructed, the legs of which fold up into two, three, four, and even five lengths. With the last the fifth point is usually telescopic. The usual tripod leg consists of three slips of wood, one of which folds up between the other two, and when opened out is locked firmly by some arrangement for that purpose. The two-fold stand is probably the simplest form of convenient stand. It should be noted that the rigidity of the camera depends chiefly upon the width apart of the upper portion of the legs attached to the tripod, the stability varying as the square of the width, and also upon the thickness and depth of the material. There are also a few forms of metal telescopic stands. These are very useful when photographing on rough and hilly ground, so that one leg can be shortened without interfering with the other.

FIG. 472.—TRIPOD CLOSED.

TRIPOD HEAD.—See **Tripod.**

TRIPOLI.—A siliceous deposit consisting of the cast-off shells of diatoms. Found in deposits of considerable thickness and extending over many miles of country. It was first imported from Tripoli, but has since been found in other places. It is largely used for polishing metals, marble, glass, etc.

TRIPOLI POWDER.—Prepared tripoli imported from Germany, and used for polishing metals, glass, etc.

TURMERIC.—The dried tubers or rhizomes of *Curcuma longa*, a native of Ceylon. The best is in small short pieces, externally yellow, internally deep orange. Unsized paper, dipped in an alcoholic solution of turmeric, is used as a test for alkalies. (See **Test Paper.**

TURMERIC PAPER.—See **Test Paper.**

FIG. 473.—CAMERA WITH TURNTABLE.

TURNTABLE.—A circular arrangement fitted in the baseboard of the camera, and to which the legs of the tripod are attached. The advantages of this contrivance are that there is no possibility of forgetting the tripod head or screw, the difficulty of trying to find the hole in the camera to fit in the screw is done away with, and the camera is much more rigidly attached to the tripod. Further, the lens can be left in the camera when packing up as it projects through the turntable.

TUNGSTATE OF SODA.—See **Sodium Tungstate.**

TURPENTINE (Formula C_{10} H_{16}).—An oleo-resinous substance flowing naturally or by incision from several different kinds of trees, as from the pine, larch, fir, etc.

Ordinary turpentine is usually obtained from the Scotch, or some species of fir. Venice turpentine is obtained from the larch. All the turpentines dissolve in pure alcohol, and by distillation yield oils termed spirits of turpentine.

It is much used as a solvent for varnishes.

TWIN LENSES.—In stereoscopic photography a camera is usually employed fitted with two lenses side by side, their centers distant about two and a half or three inches, and their foci exactly the same; for this reason they are often termed twin lenses.

ULTRA-RED RAYS.—A term applied to the rays beyond the red low end of the spectrum. From these rays, which are invisible on account of the slowness of their vibrations, the greatest heating effects are obtained. (See **Spectrum.**)

ULTRA-VIOLET RAYS.—A term applied to the rays beyond the violet or high end of the spectrum. The vibrations of these rays are too rapid for vision, but they possess greater chemical activity than any others.

UMBRELLA TENT.—A kind of collapsible dark tent for changing or developing plates. It opens out like an umbrella, but has no stick in the center, and can be placed on a table or the ground, or hung to the bough of a tree.

UNDER-EXPOSURE.—Sensitive plates, films, or papers are said to be under-exposed when the action of the light has been insufficient. An under-exposed plate appears hard, the high lights developing very black, and the shadows remain clear glass. Under-exposed plates can rarely be improved. A strong developer should be used, and with the ferrous oxalate it is a common practice to add a few drops of a very dilute solution of hyposulphite of soda.

UNDULATORY THEORY.—The theory of light that has been generally adopted. It presupposes that there exists a universal ethereal medium, pervading all space, of infinite elasticity. The sensation of light is supposed to be caused by rapid undulations or waves in this impenetrable ether. Sir John Herschel gives the following table of the number of waves composed within the space of an inch, constituting differently colored lights, and also the number of each which strike upon an object (the eye, for instance) in one second of time:

Colors of the Spectrum.	Number of Undulations in an Inch.	Number of Undulations in a Second.	Colors of the Spectrum.	Number of Undulations in an Inch.	Number of Undulations in a Second.
Extreme red	37,640	458,000,000,000	Blue	51,110	622,000,000,000
Red	39,180	477,000,000,000	Indigo	54,070	658,000,000,000
Orange	41,610	506,000,000,000	Violet	57,490	699,000,000,000
Yellow	44,000	535,000,000,000	Extreme violet	59,750	727,000,000,000
Green	47,460	577,000,000,000			

UNIFORM SYSTEM.—A system of numbering diaphragms adopted by the Photographic Society of Great Britain, taking f_4 as the standard, which is termed No. 1. The numbers are termed the U.S. numbers. (See **Diaphragm.**)

URANIUM (Symbol U; atomic weight, 180).—A valuable metal occurring as an impure oxide in pitch blende, and as carbonate in liebigite. The nitrate and the chloride are both used in photography. (See **Uranyl Nitrate** and **Uranyl Chloride.**)

URANIUM COLLODION PROCESS.—A collodion process devised by Wortley, in which uranium was used.

The formulæ are:

Plain collodion	10 ounces
Cadmium bromide	76 grains
Uranium nitrate	5 drachms
Silver nitrate	3 drachms

The manipulations necessary are precisely the same as with the ordinary collodion bromide emulsion process. The following is the preservative:

Tannin	80 grains
Gum arabic	48 grains
Sugar	32 grains
Water	8 ounces.
Gallic acid solution	4 drachms

The gallic acid solution consists of 1 part of gallic acid in 20 parts of alcohol.

The following is used as developer:

Water	320 minims
Alcohol	128 minims
Alcohol pyrogallic solution (1 in 10)	40 minims
Ammonium carbonate solution (1 in 8)	20 minims
Ammonium bromide solution (1 in 8)	20 minims

The pyro, water and alcohol solutions are first left to act by themselves, and the ammonium solutions are added later. With over-exposed plates more bromide, and with under-exposed plates more pyrogallic acid, solutions are used.

URANIUM INTENSIFIER.—See under **Intensification.**

URANIUM PRINTING.—Very pretty images can be made by this process. A variety of very pleasing terra cotta and other red colors can be obtained.

Paper is first floated for five minutes on a bath of

Uranyl nitrate	80 grains
Distilled water	1 ounce

This solution should be preserved in the dark. Instead of floating the paper the solution can be applied with a broad camel-hair brush, or a pad of wool.

When dry, the paper is exposed beneath the negative in sunlight, until the principal details are visible. It is then developed with one of the following:

1

Distilled water	1 ounce
Potassium ferricyanide	50 grains

This gives a reddish brown tone.

2

Distilled water	1 ounce
Silver nitrate	25 grains

Gives a dull gray image, which can be washed and toned in gold hyposulphite.

3

Gold chloride	1 grain
Distilled water	1 ounce

This should be brushed over the image, and gives a purplish black. The prints after development should be washed in 1 in 80 bath of hydrochloric acid, and then thoroughly washed again.*

URANIUM TONING.—See **Toning.**

URANOPHOTOGRAPHY.—See **Nomenclature.**

URANYL CHLORIDE (Formula UO_2Cl_2; Synonyms, *Chloride of Uranium, Uranium Oxychloride*).—Prepared by dissolving uranic oxide in hydrochloric acid. It occurs in greenish yellow plates deliquescent and soluble in water and alcohol. Used for toning silver prints (see **Toning**). By the action of light uranyl chloride is converted into a mixture of uranous chloride and uranous oxide. Paper coated with a mixture of it and potassium chloroplatinite and exposed to light will with hot potassium oxalate develop a uranium and platinum image.

URANYL NITRATE (Formula $UO_2(NO_3)_2+6H_2O$; synonyms, *Uranium oxynitrate, nitrate of uranium*).—Prepared by dissolving uranic oxide in nitric acid. Occurs in yellow fluorescent prismatic crystals, soluble in water and alcohol. By the action of light it is converted into a mixture of uranous nitrate and oxide. With a mixture of uranyl nitrate and nitrate of silver dissolved in collodion a printing-out paper can be made.

URIE'S MACHINE.—See **Automatic Printer.**

U.S.—See **Uniform System.**

VALENCY.—See **Automicity.**

VANADIUM (Symbol V; atomic weight 51.2).—The sensitiveness to light of the vanadium compounds, which the Brothers Lumière have so thoroughly studied, and which Gibbons records in the *Chemical News*, 1874, p. 267, has, I believe, not much practical importance in connection with positive printing. Those vanadates which I myself investigated (*Photo Archiv*, 1893, p. 210) only show sensitiveness on unsized paper, none on sized paper.

An aqueous solution of these salts may, however, be employed in actinometry. If a concentrated aqueous solution of vanadate of ammonia is mixed with its own volume of a 25 per cent. aqueous solution of tartaric acid, we obtain a clear, reddish-yellow fluid which undergoes no change in the dark, but on exposure to sunlight becomes dark olive, this occurring in about twenty minutes. During the next ten minutes the fluid becomes green, and finally blue, these stages being quite definite, and requiring no analytical means for indicating them. Should, however, a chemical reaction be required for tracing the changes, the following may be taken advantage of. The unexposed mixture of vanadate and tartaric acid gives, with diamidophenol, a soluble intensely brown-red coloring matter, and with hydrochlorate of paramidaphenol an intense violet color. When the vanadate mixture has been brought to the blue stage by exposure, these reactions do not take place, the mixture remaining almost colorless—or, at any rate, only slightly blue. Titration with permanganate of potassium may be adopted as a means of quantitatively determining the extent to which the light has acted.

A mixture of the vanadate of ammonium and citric acid is much less sensitive to light than the mixture containing tartaric acid, and the addition of alcohol still further reduces the sensitiveness. Mixtures prepared with sulphuric acid or with hydrochloric acid are insensitive.†

VARNISH.—A solution of resinous substances used for the purpose of forming protective coatings over the negative film, resisting the action of the air and moisture. Photographic var-

*E. J. Wall. † Ed Liesegang.

nishes are mostly volatile, that is to say, the solvent used can be evaporated by heat without decomposition.

A large number of formulæ for varnishes have been given from time to time. The following, however, have all been well tested, and have proved satisfactory :

NEGATIVE VARNISH. (1.)

Sandarac resin	4 parts
Spirits of wine	20 parts
Chloroform	0.5 part
Oil of lavender	3 parts

In using this varnish, it is (after filtering) poured on to the glass plate and dried by the application of heat. It gives a perfectly colorless film, and does not crack no matter how long the negative be stored away.

NEGATIVE VARNISH. (2.)

Orange shellac	2½ ounces
Mastic	½ ounce
Sandarac	2½ ounces
Oil of turpentine	½ ounce
Venice turpentine	½ ounce
Camphor	20 grains
Methylated spirit, 66 overproof	40 ounces

Some workers prefer the addition of 20 grains of mercuric nitrate, cupric nitrate or cupric sulphate to the above solution.

NEGATIVE VARNISH (3.)

Sandarac	2 ounces
Venice turpentine	½ ounce
Oil of turpentine	1 ounce
Alcohol .825	20 ounces

This formula has been recommended by W. K. Burton. Pure methylated spirit 66 overproof can be used instead of alcohol, the cost being reduced by nearly one half. This varnish is of a pale color, and requires that the negative be warmed previous to coating. The film is very hard.

NEGATIVE VARNISH. (4.)

Orange shellac	2 ounces
Sandarac	2 ounces
Canada balsam	60 grains
Oil of lavender	1 ounce
Methylated spirit	16 ounces

Like other shellac varnishes, this will require clearing to remove the wax in the lac, which is soluble in alcohol. This is done by shaking up kaolin, or prepared chalk, with the varnish, and allowing it to settle, or by treating shellac by methylated ether.

NEGATIVE VARNISH. (5.)

Sandarac	2 ounces
Seed lac	1 to 1½ ounces
Castor oil	3 drachms
Oil of lavender	1½ drachms
Alcohol	18 fluid ounces

NEGATIVE VARNISH. (6.)

Best white hard varnish	15 ounces
Methylated spirit	25 ounces

This is a quickly-made varnish; the formula for the "white hard" will be found elsewhere. Its only objection is that it takes rather longer to dry than other varnishes. It gives a very good film, however.

NEGATIVE VARNISH. (7.)

Amber	2 parts
Copal	2 parts
Mastic	1 part
Petroleum naphtha	10 parts
Spirits of wine	20 parts

NEGATIVE VARNISH. (8.)

Button lac	8 ounces
Sandarac	2 ounces
Methylated spirit	2 quarts

This is shaken at intervals for about a week and then filtered.

NEGATIVE VARNISH. (9.)

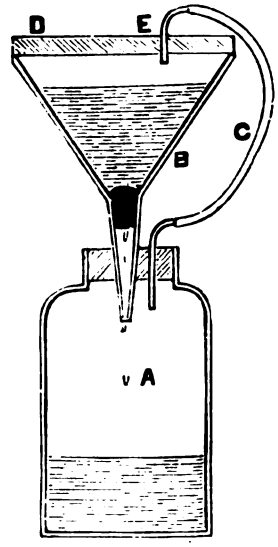
Gum sandarac	½ ounce
Gum shellac	1 ounce
Methylated spirit	10 ounces

The two principal gums used in the manufacture of photographic varnishes are lac and sandarac, or gum juniper, as it is termed in the trade. Lac is somewhat harder than sandarac, but it has an objectionable red color, while sandarac is almost colorless. Lac varnish can be easily decolorized, however, by passing it through animal charcoal broken up into small pieces, and freed from salts contained in it by treating it with hydrochloric acid and washing. Seed lac is preferable to stick lac, as it possesses less color.

Owing to the viscous nature of varnishes some difficulty is usually experienced in their filtration. The length of time required for this operation allows of a considerable evaporation of the alcohol, benzole, or other solvent used. A simple apparatus for the perfect filtration of small quantities of volatile varnishes, without loss by evaporation, is given by Mr. H. C. Standage and reproduced here.

The following description of the arrangement is given:—*

"A is a large bottle, either of glass or tin. This is hermetically closed by a cork with two holes; a caoutchouc stopper is very handy in this case, or a wide bung. B is a glass funnel, the neck of which passes through one of the holes in the cork of A, while a piece of bent glass tubing, connected with a piece of indiarubber tubing C, passes through the other hole; a plug of cotton wool—medicated wool I find the best—is put in the neck of the funnel, or else a filter paper is used. I prefer the former for both spirit and volatile varnishes. The top of the funnel is ground smooth, and a piece of mahogany made to fit accurately thereon as a cap D. A ring of rubber placed on the underside of this cap renders it air-tight. In the center of this cap is a hole, through which passes a piece of bent glass tubing E, which is connected with the other end of the rubber tubing C. The volatile varnish is placed in the funnel B, the cap put on, and as the varnish filters through into A, the air in the latter vessel is displaced, and passing through C, enters E, and so keeps up the equilibrium. The air in B becomes saturated with the vapor of the spirit; but, as such vapor cannot escape when the air is saturated therewith, no more vapor is given off from the varnish; thus, the consistency of the filtered varnish is uniform, which is not the case when it is filtered in an open funnel, because as the spirit evaporates, the proportion mixed with resin is lessened, and so the latter portion of varnish that is filtered becomes thicker than the first, due to this loss of spirit. When the plug of cotton-wool or filter-paper ceases to act well—*i. e.*, when the varnish filters very slowly—whatever is in B should be poured off, and the filtering body be replaced with fresh material."



FILTER FOR VARNISH.
FIG. 474.

FIG. 475.—VARNISH CAN WITH FILTER.

Considerable care should be taken in the purchase of the raw materials used for varnishes, as it is very necessary that they should be free from color.

Retouching Varnish.—A varnish used for retouching. It gives a rough, biting surface, which takes the lead of the retouching pencil.

NEGATIVE RETOUCHING VARNISH (1.)

Sandarac	1 ounce
Castor oil	80 grains
Alcohol	6 ounces

First dissolve the sandarac in the alcohol and then add the castor oil.

NEGATIVE RETOUCHING VARNISH. (2.)

Shellac	0.035 ounce
Sandarac	0.21 ounce
Mastic	0.7 fluid drachms
Ether	0.21 ounce

2.7 parts of pure benzole are added after the resins have dissolved in the ether.

* *Photographic News*, June 19th, 1891.

NEGATIVE RETOUCHING VARNISH. (3.)

Sandarac	½ ounce
Canada balsam	1 drachm
Sulphuric ether	7 ounces
Benzole	3 ounces

This varnish is applied cold.

LUCKARDT'S RETOUCHING VARNISH.

Alcohol	300 parts
Sandarac	50 parts
Camphor	5 parts
Castor oil	10 parts
Venice turpentine	5 parts

Monckhoven's Retouching Varnish is made by placing shellac in a saturated solution of carbonate of ammonia in water. After twenty-four hours the solution is poured off, and replaced by the same quantity of water. This should be about in the proportion of 1 to 8. The fluid is boiled under constant stirring until the lac is all dissolved. The negative, which should be thoroughly dry, is coated twice with this varnish.

Cold Varnish.—A cold varnish is one that can be used without the necessity of heating the negative. These have found much favor with amateurs, who are usually more successful with them than with the other varnishes. The simplest is the following:—

Bleached shellac	3 ounces
Borax	1 ounce
Distilled water	25 ounces

One of the principal points in the manufacture of this varnish is that the shellac must be recently bleached, otherwise it will most likely be found insoluble. It should be broken up into small pieces and heated with the borax and a little water until hot, the remaining part of the water is then gradually added.

Very good cold varnishes are prepared with amyl acetate or acetone. Hydrated acetone can be used as a solvent of sandarac. Amyl acetate is used as a solvent of pyroxyline and a very good varnish is thus formed. The formula is—

Pyroxyline	15 grains
Acetate of amyl	1½ ounces

This is coated over the negative in the same manner as collodion. It requires from twelve to twenty-four hours to dry, but gives a very hard protective film.

Varnish for Paper Negatives, Photographs, etc.—An elastic varnish for paper negatives, photographs, etc., can be prepared as follows:—

Some clear and transparent piece of dammar are crushed into small pieces. About 40 grains of this is placed in a flask and about six ounces of acetone poured over it. This is exposed to a moderate temperature for about two weeks, frequently shaking. At the expiration of this time, the clear saturated solution of dammar is poured off, and to every four parts of varnish three parts of a rather dense collodion are added, the two solutions are mixed by agitation, and the resulting liquid is permitted to settle, when it is afterwards preserved in properly closed bottles. This varnish is applied by means of a soft beaver hairbrush in a vertical direction. When first applied, the paper appears as if covered with a thin white skin, but as soon as the varnish has become dry, it gives a clear, shiny surface. Two or three coats should be given. This varnish retains its gloss under all conditions of weather, and remains elastic, this quality adapting it admirably to the purpose of varnishing photographs, etc.

Another good varnish for protecting photographs, maps, drawings, etc., is the following:

Mastic	1 ounce
Sandarac	2 ounces
Powdered glass	2 ounces
Ether, methylated, .725	5 ounces
Methylated spirit	10 ounces

The use of the glass is merely as a clearing agent. This varnish should be filtered, and can be applied by means of a spray diffuser to drawings, bromide enlargements, etc.

Another formula for the same purpose is:

Water	320 parts
White gum lac	32 parts
Borax	8 parts
Carbonate of soda	2 parts
Glycerine	2 parts

Dissolve the borax and the carbonate of soda in 160 parts of warm water, then add the gum lac in small pieces and stir until solution is completed. Filter and add the glycerine and remainder of the water. After a day or two a deposit will settle, when the clear liquid is decanted.

A good varnish or lacquer for photographs can be prepared as follows:

Dammar	1.4 ounces
Acetone	6.3 ounces

The resin should be nearly dissolved in about a fortnight, if the bottle (well-stoppered) is allowed to stand in a warm place. The solution should then be poured off, and applied several times with a soft brush.

Varnish to Imitate Ground Glass.—This can be made with—

Sandarac	90 grains
Mastic	20 grains
Ether	2 ounces
Benzole	½ to 1½ ounces

The amount of benzole determines the nature of the matt obtained.

Colorless Varnish.—Dissolve 2½ ounces of shellac in a pint of rectified spirits of wine, boil for a few minutes with five ounces of well-burnt and recently-heated animal charcoal. A small portion of the solution should then be filtered, and if not colorless, more charcoal is added; when all the color is removed, press the liquid through a piece of silk, and afterwards filter through fine blotting paper. This varnish should be used in a room at 60 deg. Fahr. It dries in a few minutes, and is particularly suitable for prints, photographs, etc.

White Hard Varnish.—This is prepared as follows:

Sandarac	2 pounds
Spirits of wine	1 gallon
Venice turpentine	18 ounces

Fifteen parts of this, diluted with 25 parts of methylated spirit, forms a very good negative varnish.

Amber Varnish.—To make a good amber varnish, the following formula will be found a good one:

Amber	6 pounds
Oil of turpentine	4 gallons
Oil of linseed	2 gallons

Dead Black Varnish.—A very useful varnish for blackening the insides of the camera, dark slides, etc., can be prepared as follows:

Alcohol	8 ounces
Lampblack	2 ounces
Shellac	1 ounce

Dissolve the shellac in seven ounces of the alcohol, and mix the lampblack with the remaining ounce; then add the two together, and the varnish is formed. (See also **Black.**)

Anti-rust Varnish.—A varnish for preventing metal instruments, etc., from rusting:

Resin	120 parts
Sandarac	180 parts
Gum lac	60 parts
Essence of turpentine	120 parts

Take the first three ingredients in a powdered condition, and digest them by means of a regular heat until melted, then add the turpentine very gradually, stirring the whole time. The mixture should be digested until dissolution, then add rectified alcohol 180 parts. Filter through fine cloth on thick, bibulous paper, and preserve in well-stoppered bottles.

Varnish for Backing Positives.—This is made with—

Spirit of turpentine	6 ounces
Asphaltum	2 ounces
White wax	2 scruples
Lampblack	1½ scruples

Crystal Varnish for Ferrotypes.—

Dammar	25 grains
Benzole	1 ounce

Black Varnish.—

Gum sandarac	½ ounce
Gum shellac	1 ounce
Methylated spirit	10 ounces
Lampblack	2 ounces

Mix the lampblack with a little of the methylated spirit, and add to the gum solution. A black varnish similar to this is sold as Bates's Black, a very useful varnish for blocking out portions of negatives, and for a variety of other purposes.

Dissolve in a warm place, and filter through flannel.

Waterproof Varnish.—A useful varnish for coating wooden or paper dishes, which will then last some time, provided alkaline substances are not used in them.

Colophony	2¼ ounces
Shellac	½ ounce
Turpentine	9 ounces
Yellow wax	⅛ ounce
Methylated spirit	20 ounces

Melt the wax in a water bath, and add the resin and lac, then the turpentine, and lastly the spirit.

Iodine Varnish.—Prepared by the addition of ½ to 1 part of iodine to 100 parts of negative varnish. It is used for coating the back of thin negatives to cause them to print slower, or it can be applied to parts only.

Varnish for Sketching Lantern Slides.—It is very often useful to have some method of writing or drawing on a piece of glass, to be used as a lantern slide. For this purpose the following varnish will be found serviceable:

Ether	50 parts
Sandarac	1 part
Mastic	1 part
Benzene	10 parts

This will give a rough surface, which can be used for drawing on. After the drawing or writing is made, it is flowed over with—

Ether	100 parts
Sandarac	3 parts
Mastic	3 parts

Which produces, when dry, a perfectly smooth and transparent surface.

Colored Varnishes.—Colored varnishes may be made with the following:

Seed lac	10 parts
Dried spirit	80 parts

To which is added any of the aniline colors soluble in alcohol. By this means an excellent ruby varnish can be made for dark-room windows, etc.

VARNISHING.—Negatives from which a number of prints are required or which are intended to be kept for probable future use should be varnished with a protecting coating of a lac solution. Suitable varnishes for all kinds of work will be found under **Varnish.**

The negative should be varnished as soon as it is quite dry, and should be handled as little as possible previous to the operation. Touching the surface of the film makes it repellent to the varnish, and consequently it is more difficult to get an even flow over the surface.

Negatives from which extra large quantities of prints are required should be given a preliminary coating of plain collodion.

Although the operation of coating a negative with varnish may seem simple enough, yet few manage it properly without considerable practice. First of all the varnish should be quite clean, and kept free from impurities, and before putting it on the plate should be carefully wiped over with a broad camel-hair brush. Another important consideration is that the room where the coating takes place be quite free from dust, as it is astonishing how soon particles of all sorts of matter floating in the air settle on the sticky plate. The first operation is to gently warm the negative, but not by any means to make it too hot. A little of the varnish is then poured on about the right hand top corner, and with a little manœuvering this pool can be made to run over the whole of the plate, and the surplus run off into a separate bottle kept for the purpose. The plate is then rocked in front of a clear fire or a vertical gas stove. If a pneumatic holder be used the whole of the plate can be coated, but if not, the bottom left hand corner is held by the ball of the thumb, and a small corner left uncoated.

Several methods of varnishing have been recently introduced, with which no heat is required.

Although a coating of varnish protects the sensitive gelative film from the influences of moisture, yet it is no proof against rain spots or drops of water, which, if not quickly removed, will soon work their way through the varnish and destroy the film.

VARNISH, REMOVING.—The varnish can be removed by means of a pad of cotton-wool saturated with spirits of wine or turpentine.

VASELENE, commonly called Vaseline.—A pale yellow translucent semi-solid substance, consisting of a mixture of the hydrocarbons $C_{16}H_{34}$ and $C_{20}H_{42}$, obtained by treating the undistilled portion of petroleum with superheated steam and filtering while hot through animal charcoal. It is insoluble in water, slightly soluble in alcohol, but dissolves freely in

ether, chloroform, benzene, and turpentine, is miscible in all proportions with fixed and volatile oils, melts at 35 deg. to 40 deg., and commences to fume at 160 deg. Its density in the melted state is .840 to .866. Pure vaselene is not affected by air. It is used for a large variety of purposes. A little rubbed round a glass stopper will prevent it from sticking, and a layer over a corked bottle will effectually prevent the air from entering and destroying the contents. It is also used in making paper or paper negatives transparent.

VASELINE.—The popular name given to Vaselene (*q.v.*).

VEGETABLE PARCHMENT.—See **Parchment Paper.**

VEHICLE.—In order to spread the sensitive salts upon hard repelling substances, such as glass, etc., it is necessary that some substance be used wherein they may be suspended. The suspending substance is termed the "vehicle," and the ones commonly used are collodion, albumen, gelatine, etc.

VENICE TURPENTINE.—See **Turpentine.**

VENTILATION.—The ventilation of the rooms in which photographic operations are carried on is a point which should be carefully looked into. Too frequently is the dark room entirely without ventilation, and in consequence the health of the operator suffers. Many photographic sensitive materials, too, require to be stored in a properly-ventilated room. Plates, papers, etc, are often spoilt, and the cause apparently inexplicable. Usually the dealer or manufacturer suffers, when in reality the cause is due to their being stowed away on high shelves where foul air accumulates. In ventilating the dark-room care must, of course, be taken that light is not admitted at the same time. A convenient plan is to bore a number of holes (about 1 in. in diameter) in the bottom of the door, and outside a piece of wood is fixed in a slanting direction as shown in Fig. 476. This allows of the entrance of air without light. Another arrangement should be made somewhere high up the wall, close up to the ceiling, where the foul air can escape, so as to have a current of fresh air passing through, carrying away the noxious gases.

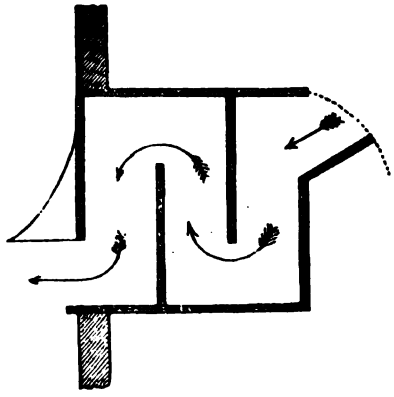


FIG. 476.

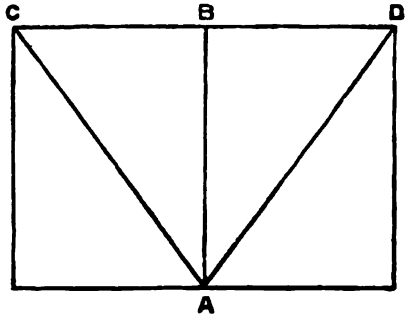


FIG. 477.

VERGARA FILM.—See **Woodbury Film.**

VEST CAMERA.—A small detective camera worn under the vest, the lens protruding through a button-hole. See Fig. 478. About six round pictures of the size of a half dollar are taken upon circular dry plates.

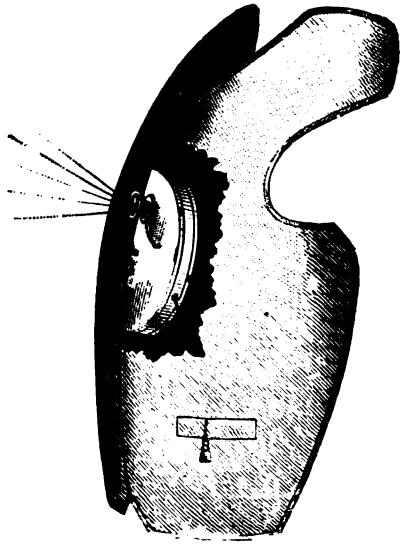


FIG. 478.—VEST CAMERA.

VERTICAL CAMERA.—See **Camera.**

VICTORIA SIZE.—A size of picture 3 × 4¼ inches, size of mount 3½ × 5 inches.

VIEW FINDER.—A little instrument used in instantaneous photography. In photographing rapidly moving objects it is necessary that some means should be employed to enable the operator to see whether or not the object will appear in its proper position on the plate. With a finder attached to the camera it is possible to see exactly when the object is in position on the plate, the shutter is instantly released and the picture secured.

There are various kinds of finders on the market, the usual form being that of a small camera obscura.

Wall gives a method in which the focusing screen is used. When turned back over the top of the camera, it should have the lines drawn on it, as shown in

Fig. 477. Then when the eye is placed at A looking along AB, the object when opposite this will be in the center of the plate, and CAD is the angle included by the lens. (See also **View Meter.**) The Scovill Magic Finder is a neat contrivance easily adjustable. (Fig. 479.)

FIG. 479.—MAGIC FINDER.

Looking through the finder from the proper distance, toward the view to be taken, the operator sees before him a correct, right side up, and delightfully brilliant and sharp miniature picture of the view before him, the little frame taking in the full picture projected by means of an instantaneous lens on the ground glass of his camera. Two circles, marked in the exact centers of the front and back surfaces of the combination, serve to enable the operator to bring any certain part of the view to the exact center of the picture by placing the eye so that the two circles cover each other, and at the same time adjusting the camera so that the selected part of the view appears inside the circles.

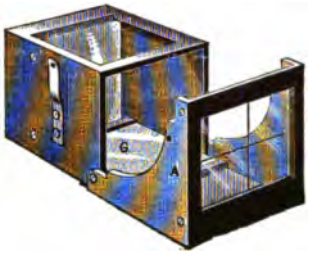


FIG. 480.

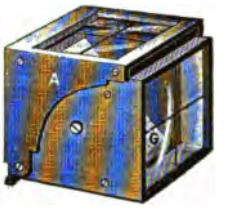


FIG. 481.

Figs. 480 and 481 show a new finder which may be used either by reflection or direct vision. There is only one position in which to place the eye for the correct location of the subject upon the plate. The camera should be so held that the cross lines on the two glasses are superposed.

VIEW LENS.—See **Lens.**

VIEW METER.—An instrument for readily ascertaining the amount of view that will be depicted upon the ground glass with the lens used. Thus the operator can see the view at a glance without the trouble of setting up and arranging the apparatus. In some view meters the landscape is seen through blue glass, which practically reduces the different colors to monochrome, so that the operator can get a better idea of the actinic powers of the lights and shades of the proposed view.

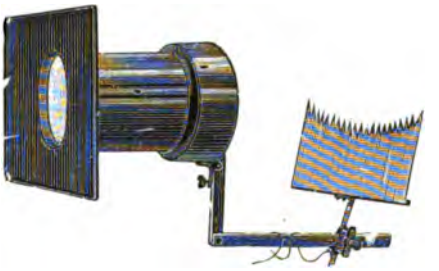


FIG. 482.—ARRANGEMENT FOR VIGNETTING IN THE CAMERA.

VIEW MOUNT.—See **Mount.**

VIGNETTING.—A method of positive printing by which the margins of the picture are made to gradually fade away. This softness is produced by many different ways.

The vignette is usually made of cardboard, with a hole cut in it, of a size and shape to suit the requirements of the picture. The edge of the hole is then cut all round with teeth or slits, and then covered over with a piece of thin tissue paper to give softness to the vignetting. This is placed over the negative during the printing operation. An important point is the distance between the negative and the vignetting card. Usually this should be at least about half an inch. The greater the distance, however, the smaller should be the opening. (See Figs. 484 and 485.)

FIG. 483.—MAGIC VIGNETTER.

There are besides this a variety of vignetters, some of glass, with oval or other shaped openings, surrounded by a gradually deepening margin of a non-actinic color; others of zinc with cut-out openings, having serrated edges, and other patent ones, which can be adjusted to any size or shape of opening.

Considerable care and thought are required in producing a successful vignette. They can afterwards, if preferred, be "greyed" by darkening the white margin.

Figs. 482 and 483 show arrangements used for vignetting during the exposure, one being used in front of the lens and the other placed in the interior of the camera.

VINIC ETHER.—See **Ether.**

VIOLET PRINTS.—Cyanotype "blue" prints may be toned to dark violet color by the following method:—

The blue prints are treated with a solution of

Caustic potash	1 part
Water	300 parts

The blue color will be decomposed, and a rusty yellowish-brown substance—ferric hydrate*—will be left on the paper. If then a solution consisting of

Alcohol—90%	25 parts
Water	30 parts
Gallic acid	4 parts

be poured over the rusty color a fine violet black will be the result.

VIRTUAL IMAGE.—See **Image.**

VISION (Lat. *video*—to see).—Lit. the faculty of seeing; that power by which we perceive the forms and color of objects through the sense of sight.

The study of the eye, and the analogy it bears to the photographic camera and lens, is one that is full of interest to the photographic student. The eye is a natural camera obscura lens and diaphragm. It is placed in a bony cavity termed the orbit, and maintained in position by the muscles which serve to move it, by the optic nerve, the conjunctiva, and the eyelids. It is about the same size with most persons, for, although it appears to differ very greatly with many, it is in reality the varying aperture of the eye-lids that makes it appear larger or smaller.

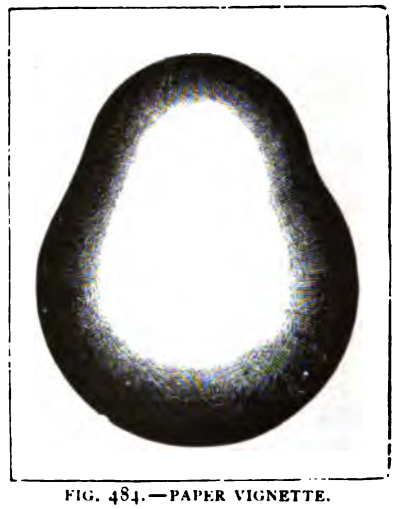


FIG. 484.—PAPER VIGNETTE.

The shape of the eye is that of a spheroid, the curvature of which is greater in the anterior than in the posterior part. It is composed of the following parts:—The *sclerotica*, or white of the eye, which serves for the attachment of the muscles; a transparent medium in front of the eye, through which we see, termed the *cornea*, a tough, velvety membrane, termed the *choroid*, on the inner surface of which is a dark substance preventing internal reflection. The retina is the inmost coat of all, and is composed of layers of nerve-cells, which transmit their impressions to the brain *via* the optic nerve which, communicating directly with the brain, is the immediate seat of vision.* In the center of the iris of the eye is a circular opening called the pupil Behind the pupil and iris is the crystalline lens, a firm and transparent body through which the rays of light pass on their way from the pupil to the retina. It is a single, though not a simple, bi-convex lens, about half-an-inch in diameter, and with a little over half-an-inch focus. The posterior chamber is filled with the vitreous humor, which shapes the whole constructions.

From this description of the structure of the eye its resemblance to the photographic camera will be apparent. The pupil is the aperture, the crystalline the condensing lens, and the retina the screen on which the image is formed.

The image thrown upon the retina is inverted, consequently a natural question arises, Why do we not see objects upside down? The explanation is that "the image simply causes a stimulation of the optic nerve, which produces a change on some part of the brain, and it is only of this change that we are aware, and not of the image itself.

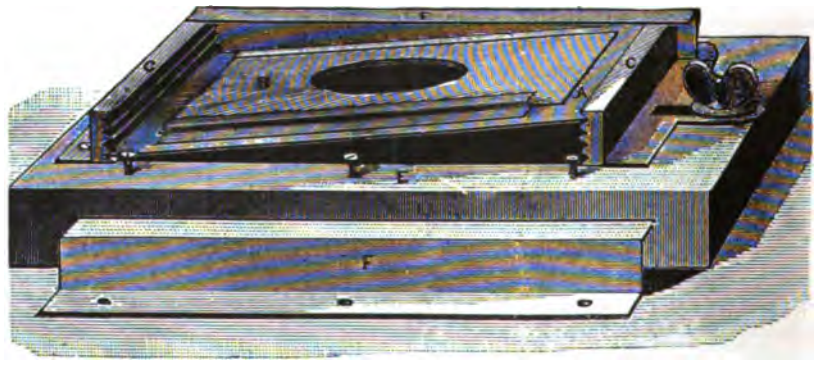


FIG. 485.—MCDONALD'S VIGNETTE.

* The retina is not simply a dead screen receiving and reflecting the various impressions of light which fall upon it. It is a forest of *living* nerves, which not only distinguish between the intensities and colors of the rays which touch them, but also recognize the direction in which they come. Thus the inversion of the image, as far as the sensation of the retina is concerned, does not exist. If the retina perceives the rays from the summits of objects as coming down to it, and those from the bases as *coming up*, and thus regarding *the object*, and not the (to it) invisible image formed on its own substance, this nerve screen *sees* everything in its proper position. It is a natural error to think of the eye as looking at the image formed on its own retina, but a little thought will show us that such an idea is parallel to the absurdity of hoping to see one's own face without a glass or equivalent reflection. It is then upon the sensitive screen of the retina that the light rays, collected and grouped by the eye lens, make their impression. The nerves of this organ, like those of others, have certain limits to the range of their co-existent perceptions. Thus, just as we cannot hear a whisper in the presence of the rattle of a train, or taste a delicate flavor if mingled with a bitter draught, so we cannot perceive a faint impression of light in presence of another of far greater intensity.—*Prof. Henry Morton.*

The optic angle is the angle formed between the principal optic axes of the two eyes when they are directed toward same object. This angle is, of course, smaller the greater the distance of the object.

The visual angle is the angle under which an object is seen. Taking the same distance, this angle increases with the size of the object, and with the same sized object it decreases as the distance increases. It is therefore evident that objects appear smaller the greater the distance they are from the eye.

A single eye sees most distinctly any point situated in its principal axis, and less distinctly other points towards which it is not directly looking, but which are still within its angle of vision. It is able to judge the direction of any such point, but unable by itself to estimate its distance. Of the distance of an object it may be able to judge by loss of color, decrease in magnitude, indistinct outline, etc.; but if the object be near, the single eye is not infallible with these aids.*

When both our eyes are directed upon one single point we then have a power of judging the distance of that point in comparison with that of any other point, and this power we seem to gain by the sense of the amount of effort required to cause the optical axes to converge upon one point and upon another.

VISITE, CARTE DE.—See **Carte de Viste.**

VISUAL FOCUS.—See **Focus.**

VISUAL RAY—See **Ray.**

VITRIOL.—An old name for all sulphates, as "White," "Blue," or "Green" vitriol. Sulphuric acid being made by decomposing these, was called "Oil of Vitriol," or "Vitriol," *tout court!*

VOLATILE ALKALI.—See **Ammonia.**

VOGEL'S INTENSIFIER.—An uranium intensifier devised by Vogel. It consist of

Uranium nitrate	1 gramme
Red prussiate of potash	1 gramme
Glacial acetic acid	20 grammes
Water	200 grammes

This has a strong intensifying action upon the plate when immersed in it. Local intensification can be accomplished with this solution by applying with a brush. The intensifier can also be removed from the whole or parts only with a dilute solution of ammonia. After intensifying, the plate is washed for about fifteen minutes. Longer washing will reduce, the water gradually dissolving the brown substances which affect the intensification

VULCANITE.—A hard, non-elastic variety of vulcanized rubber, used for making a variety of objects, among which may be mentioned dippers, silver baths, photographic dishes, etc. It is not affected by water or any indiarubber solvents

Sheets of polished vulcanite are often used for surfacing gelatine prints. All that is necessary with these is to thoroughly cleanse and squeegee the print firmly to the plate. When dry it will came away with a polished surface slightly inferior to that obtained with a glass plate. The risk of sticking is not so great, however, as with glass., and, further, no special preparation is required.

VULCANIZED RUBBER.—Caoutchouc, or indiarubber, treated with sulphur, to render it insensible to atmospheric changes; more durable and more suitable for a number of purposes.

WARNERKE'S PROCESS.—A simplified collotype process, invented by M. Raymond, of Paris, and introduced in this country by Warnerke. The printing surface employed is vegetable parchment, coated with a suitable gelatine. This is sensitized in a bichromate bath, and then squeegeed on to a talced glass. When dry, it can be stripped from the glass, and is ready for printing from, under a reversed negative, the exposure being prolonged "until the details corresponding with the most opaque parts of the negative are discernible." The time required varies, of course, with the actinicity of the light and the density of the negative. After exposure beneath the negative the parchment is removed, and the back of it exposed a second time for about five minutes in order to more firmly fix the gelatine film to the parchment and to diminish the swelling of the gelatine, and consequently the relief. The next operation is to wash the bichromate from the film in several changes of water; it is then blotted and hung up to dry. The dry film is immersed in water for about half an hour, the superfluous moisture blotted off, and the parchment stretched over a wooden frame. The apparatus for holding the parchment consists of solid wooden board as a base, and a clamping frame. After it is stretched on the frame the wooden block, which is smaller but thicker than the frame, is placed under it, and the frame lowered. The block being thicker raises the parchment, and renders it perfectly and tightly stretched.

* "Ganot's Physics."

The gelatine surface is then covered for an hour with a solution of

Water	10 ounces
Glycerine	24 ounces
Ammonia	1 ounce

This renders the gelatine better permeable to moisture, and causes it to repel the printing ink.

After about an hour the glycerine solution remaining on the surface is blotted off with a soft rag dabber, and it is ready for printing from.

A good collotype ink is required ; this is spread evenly over the surface with a glue roller, a sheet of paper laid on it, and this backed with a piece of stout, but fine, felt, and the whole placed under a press. An ordinary letter-copying press answers the purpose. Pressure is applied and removed, and then the paper will be found to have received an impression of the collographic plate. For clean margins, slips of oiled paper or cut-out masks should be laid on the printing surface before the paper is applied. After about three or four dozen impressions have been taken off, the plate is re-moistened with a solution of glycerine and water.

FIG. 486.

FIG. 487.

WARNERKE'S SENSITOMETER.—See **Sensitometer.**

WASHED EMULSION.—For information regarding the manufacture of washed emulsions, see **Collodion Emulsion (Washed).**

The following formulæ are given in the *British Journal Almanac* :

WASHED EMULSION (for Landscapes).

No. 1.

Ether, s.g. .720	4 fluid ounces
Alcohol, s.g. .820	2¾ fluid ounces
Pyroxyline	40 grains
Castile soap dissolved in alcohol	30 grains
Bromide of ammonium and cadmium	84 grains

Sensitize with one hundred grains of nitrate of silver dissolved in one ounce of boiling alcohol ; and after standing ten days, add a further twenty grains of silver, dissolved as before in two drachms of alcohol.

No. 2 (Rapid).

Ether, s.g. .720	4 fluid ounces
Alcohol, s g. .820	2½ fluid ounces
Pyroxyline	40 grains
Castile soap	30 grains
Bromide of ammonium and cadmium	56 grains

Sensitize with 125 grains of nitrate of silver, dissolved, as before, in one ounce of alcohol with the aid of heat. In twelve hours' time add thirty grains more of the double bromide of ammonium and cadmium dissolved in half an ounce of alcohol.

FOR WASHED EMULSION (for Transparencies).

Ether, s.g. .720	5 fluid ounces
Alcohol, s.g. .820	3 fluid ounces
Pyroxyline or papyroxyline	60 grains
Bromide of cadmium and ammonium	100 grains
or Bromide of zinc	96 grains
Hydrochloric acid, s.g. 1.2	8 minims

Sensitize with twenty grains of nitrate of silver to each ounce, dissolved in a minimum of water with two drachms of boiling alcohol. Allow to stand for two or three days.

N. B.—In the three last formulæ, the emulsion after being allowed to ripen for the time stated, should be poured into a dish and allowed to become thoroughly dry. The mass of dry emulsion is then washed, to remove all the soluble salts, and is then again dried and redissolved in equal parts of ether and alcohol, at the rate of from twenty to twenty-four grains to the ounce of solvents.

WASHING.—The operation of washing the negative and positive prints is performed for the purpose of totally eliminating the sodium hyposulphite and other soluble subtances. Considerable importance is attached to this operation, as upon it depends, to a great extent, the permanency of the negative or positive print.

For negatives, the handiest contrivance is a light wire rack, holding about a dozen negatives, and which can be placed in a suitable zinc or porcelain vessel, through which a running stream of water can be made to flow. With an arrangement of this kind, negatives should be thoroughly washed in about an hour.

In washing prints we have also to prevent them from clinging together. Several arrangements have been contrived and placed upon the market which answer the purpose very well. The water should be emptied quite away several times, the prints drained, and placed in a fresh supply of clean water.

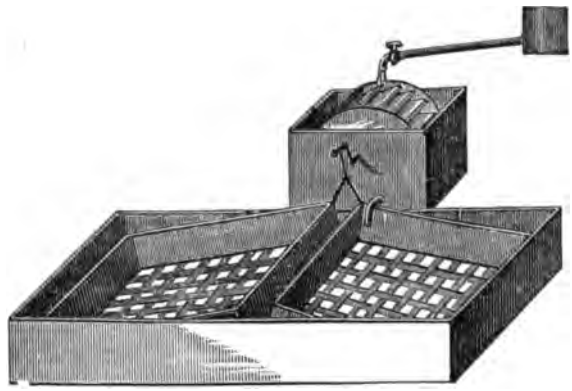


FIG. 488.

To lessen the time of washing many so called hypo-eliminators have been devised, but with most of these, however, another compound is formed at least as injurious to the permanency of the print as the hypo itself.

Most authors recommend washing the prints in a running stream of water, but a little consideration will show that a number of complete changes will be far more efficacious. We can prove this by experiment. In a large basin of water empty a bottle of strong dye, and allow a stream of water to flow into the basin, and out over the sides. The time taken before the water becomes perfectly colorless will be astonishing. Now, if we simply empty the basin and fill it up again, and repeat this operation but twice, the water will contain no trace of the coloring matter. A similar effect takes place with the hypo, except that the latter being colorless it is not noticeable. The most perfect method of eliminating the hypo from prints is one which, although somewhat tedious and for large numbers of prints hardly possible yet for special work where great permanency is required, might be of great advantage. The prints are washed for a quarter of an hour or so in clean water. Another vessel containing clean water is then arranged near at hand, and each print laid on a sheet of clean glass and squeegeed back and front to remove all possible moisture. It is then placed in the fresh water, and another print treated in the same manner. When all the prints have been subjected to this treatment the water in the first vessel is then changed, and after about another quarter of an hour the prints are again squeegeed and placed in the fresh water. By repeating this operation, say, three or four times, using fresh water each time, the prints should be thoroughly well washed and all traces of hypo eliminated. By this method the length of time the prints are required to remain in the water is considerably lessened, and this is always an advantage, as with a too long immersion in water the albumen has a slight decomposing action which is fatal to permanency.

Regarding the length of time required in washing to thoroughly eliminate the hypo we cannot do better than give here the excellent experiments of Messrs. Haddon and Grundy, and in their own words: "In carrying out a research on the amounts of silver in hypo left in albumenized paper at different stages of washing, we had two objects in view; firstly, to determine the time the print should be washed; and, secondly, to endeavor to determine the cause of the fading of the finished print.

Three sheets of albumenized paper from the same quire were sensitized on a fifty-grain neutral solution of nitrate of silver and allowed to dry in the dark. These were then cut into pieces $5\frac{1}{2}$ in. × $8\frac{1}{2}$ in. The pieces from one sheet were marked A, from the next B, and from the third C.

The paper thus cut up and marked was washed for ten minutes in running water till all free silver had been removed.

Two of these pieces, taken from different sheets, which could be easily recognized from the letters on the back, were placed on one side, in order to determine the amount of sulphur originally present in the paper and also the amount of silver that had to be removed by the fixing agent.

The remainder of the paper was placed in a pint and a half of a twenty per cent. hypo bath; and as this gave a little more than two ounces of hypo per sheet of paper, we consider we were on the safe side, as Captain Abney says that one ounce of hypo will fix three sheets of paper.

The hypo bath was tested before and after use, and was found to be slightly alkaline to litmus. The temperature was 22.4 deg. C.

The prints were kept in the bath with constant changing for fifteen minutes. Two pieces (again from different sheets) were then taken and allowed to drain for five minutes, and the total sulphur and the remaining silver to be removed by washing determined.

The remaining pieces were then placed in a large vessel filled with water and into which water was constantly flowing. The temperature of the water was 13 deg. C. During the first hour the pieces of paper in the water were constantly turned over in order to prevent them sticking.

Two pieces were removed at the end of 5, 10, 15, 25, 40, 60, 90 and 120 minutes, and 19 hours, and the amounts of silver and sulphur remaining in them determined.

The estimation of the sulphur and silver in the papers was carried out as follows: In each case the two pieces of paper were allowed to drain for five minutes, and then torn up into small pieces and placed in a large beaker, with a mixture of 100 c.c. of nitric acid and 200 c.c. of strong hydrochloric acid (free from sulphur), covered with a dark glass, and heated on a sand bath till the paper was completely destroyed. The solution was then taken down to dryness, and 250 c.c. of pure distilled water and three drops of hydrochloric acid added, and the whole heated to boiling, allowed to cool and filtered, and the filter paper and beaker washed with boiling water. The filtrate was heated to boiling and chloride of barium added, which precipitated all the sulphate present as barium sulphate. This was then collected on a filter, dried, and weighed in the usual way, and from this the amount of sulphur present in the paper calculated.

The chloride of silver on the filter was then dissolved out with ammonia, and precipitated by means of nitric acid, filtered off and treated in the usual manner.

The figures obtained are as follows:

1.	Weight of sulphur in original paper	.0050 grammes
2.	" in water adhering to paper	.000032 grammes
3.	" in paper fixed but not washed	.2243 grammes
4.	" after 5 minutes' washing	.0063 grammes
5.	" 10 "	.0045 grammes
6.	" 15 "	.0048 grammes
7.	" 25 "	.0044 grammes
8.	" 40 "	.0043 grammes
9.	" 60 "	.0046 grammes
10.	" 90 "	.0047 grammes
11.	" 120 "	.0045 grammes
12.	" 19 hours' "	.0047 grammes

The amount of sulphur in original paper has been subtracted from results 4 to 12 inclusive.

1.	Weight of silver in paper unfixed	.0734 grammes
2.	" " fixed but not washed	.0086 grammes
3.	" " after 5 minutes' washing	.0051 grammes
4.	" " 10 "	.0035 grammes
5.	" " 15 "	.0037 grammes
6.	" " 25 "	.0037 grammes
7.	" " 40 "	.0033 grammes
8	" " 60 "	.0036 grammes
9.	" " 90 "	.0038 grammes
10.	" " 120 "	.0040 grammes
11.	" " 19 hours' "	.0039 grammes

From these figures it will be seen that after five minutes' washing 97.2 per cent. of the sulphur originally present has been removed, after ten minutes 98 per cent., and that, however long-continued the washing, no more of the sulphur can be eliminated. Turning to the silver, we find that as the paper comes from the fixing bath it has lost 88.3 per cent. of its silver; after washing for five minutes, 93.1 per cent.; and after ten minutes, 95.3 per cent. After ten minutes' washing the amounts of silver and sulphur remain constant.

It is evident from these figures that the permanency of a print does not depend so much on the washing it receives as on its thorough fixing; and we are strongly of opinion that the best way of removing all the silver is not by using two baths of hypo in succession, but by washing for about five minutes after the first bath, and then soaking in a second fresh bath of hypo.

In what form the silver occurs in the paper, whether as the insoluble $AgNaS_2O_3$ or the soluble $Ag_2Na_3S_2O_3$, held in a sort of a "loose combination" with the films of the paper, we are unable to state. However, the fact remains that, after a more thorough washing and fixing than prints generally get, .246 of a grain of silver remains in each 22 x 17 in. sheet of paper, and this, which is probably in the form of hyposulphite in the presence of light and organic matter, is reduced to silver sulphide, and will easily account for the yellowing of the whites of prints after a time."

In order to test whether the hypo has been thoroughly eliminated from the prints, several methods have been devised. The simplest is the permanganate test. In a pint of distilled water one grain of permanganate and ten grains of potassium carbonate are dissolved. This will give a pink solution. A little of the water in which the prints have been last soaking is now poured into a clean white glass bottle, and to it is added four or five drops of the permanganate solution.

If the water be quite pure the addition of the solution will give it a faint pink tinge, but if any trace of sodium hyposulphite be present this color will be of a light green. After the addition of the permanganate solution the bottle should be well shaken, allowed to stand for about ten minutes or so, and then carefully examined against a white surface.

Another method commonly employed is that known as the "starch iodide test." A small piece of starch, about the size of a pea, is boiled in a quarter of an ounce of water until a clear solution is obtained. To this is then added one drop of tincture of iodine (iodine dissolved in alcohol), which will give it a dark blue color. Two test tubes are now required. Into one is poured some of the last washing water to be tested, and into the other some plain distilled water. One drop of the test solution is now added to each tube, and both well shaken. The next point is to examine the two tubes side by side in front of a piece of white paper. Hypo will cause the blue color to disappear, so that if the washing water does not present as blue an appearance as the other tube containing the distilled water only, it may be decided that hypo is still present.

Dr. Bannon recommended* silver nitrate as a very delicate test for hyposulphite of soda. A print should be removed from the washing apparatus, and the water drained from it into a test tube. This is then heated, and a few drops of a silver nitrate solution added to it. It is stated that even if so small a quantity as the one ten-thousandth part of hypo be present a black precipitate will be formed, while a smaller amount will produce a precipitate of a yellow color.

WASTE.—All waste material, papers, solutions, etc., containing gold, silver or platinum should be saved for the extraction of the precious metals. See **Residues**.

WATCH CAMERA.—A small camera which when closed has the appearance of an ordinary watch. On pressing a spring a series of about half-a-dozen tubes shoot out into position, and the camera is formed. See fig. 489.

FIG. 489.

WATER (Formula, OH_2).—A clear colorless liquid devoid of taste and smell and possessing a neutral reaction. Pure water is tasteless and colorless, except in thick layers. It boils at 100 C. (212 Fahr.), and becomes solid at 0 C. (32 Fahr.) It is undoubtedly one of the most important substances in nature; it is also the most widely distributed, occurring in three physical states, *i.e.*, liquid, gaseous and solid. In its liquid state it forms the oceans, rivers, lakes, which occupy nearly three-fourths of the whole surface of the earth. In its solid state it forms ice and snow, existing permanently at the polar regions, and, as a vapor, is an important constituent of the aerial envelope of the earth.

Pure water is not found in nature, owing to the fact that it dissolves a portion of whatever it comes in contact with. Rain is the purest form of natural water, but contains certain gases, which it collects from the atmosphere during its descent to the earth.

Water taken from wells, springs, rivers, lakes, etc., differs very much, according to the nature of the earth or rocks over which it passes, or upon which it lies. Among the various substances found dissolved in water taken from different places may be mentioned the following :† Sodium sulphate, sodium chloride, magnesium sulphate, magnesium chloride, magnesium carbonate, calcium sulphate, calcium carbonate, sulphuretted hydrogen, potassium sulphate, potassium chloride ; phosphates, bromides and iodides of calcium, aluminum, sulphate, ferrous carbonate, carbonic acid, silica, and a large variety of vegetable substances.

Water from natural sources is commonly classified as *hard* and *soft*, terms which are applied to it according to the manner in which it acts upon soap. If, for instance, we rub a piece of soap in "soft" water, such as ordinary rain water, it is not a difficult matter to speedily produce a lather, and its cleansing powers are easily made use of; but if on the other hand, the water is what is termed "hard," spring water for instance, it will be found that the soap requires a much longer time and considerably more friction to produce the required lather. Curdy flakes will also make their appearance. The reason of this is that soap is formed by the combination of a fatty acid, with an alkali manufactured by boiling oils and fatty substances, with potash for soft soap, and with soda for hard soaps. The action of the soda is to rob from the oil or fat two acids, stearic and oleic acid, and with which it unites to form hard soap, which would be chemically termed a mixture of stearate and oleate of sodium. If we take some soapy water and add a little magnesium sulphate (Epsom salts) solution to it, curdy flakes will be produced in just the same manner as when soap is rubbed in hard water, the soap losing its properties of frothing. The magnesium sulphate has decomposed the soap, forming sodium sulphate, which remains dissolved in the water, and insoluble curdy flakes consisting of stearate and oleate of magnesium. A similar effect is produced by the hard water, the hardness being caused by the presence of

Photographic Times, 1880. †Bloxham's "Chemistry."

different calcium and magnesium salts, all of which have a decomposing action upon the materials contained in the soap. If the hardness be caused by the presence of calcium bicarbonate, it can be got rid of by boiling, as can also most of that due to magnesium bicarbonate. The effect of boiling is to drive away the carbonic anhydride that causes these salts to become soluble, and they will be precipitated.

When spring, river, or well water is boiled in a kettle, a thick fur or incrustation is soon formed in the interior of the vessel. This is usually of a brown color, and the harder the water the more rapid will be the deposit. The explanation is that when natural water is boiled the carbonic acid gas contained in it is expelled, and, as the calcium, magnesium, and iron carbonates are not soluble in water which does not contain carbonic acid, they are precipitated, forming a succession of those layers on the bottom and sides of the vessel in which the water is boiled. This deposit must be removed, and is very annoying in the case of steam boilers, as it is a bad conductor of heat, and in consequence a great waste of fuel is occasioned. A small marble placed in the kettle will lessen the amount of deposit upon the sides. It will be understood that when water is boiled for some time it becomes much softer, owing to the precipitation of the salts. When the hardness can be removed by boiling, it is termed "temporary hardness," but if due to such substances as sulphate of lime, which is not thrown out of solution by boiling, it is termed "permanent hardness."

The organic matter contained in water may be due to several causes. It may be dissolved from the earth, or it may be due to the decomposition of animal or vegetable substances, or from sewage or drainage which has gained access to it.

There are a number of fine analytical tests for the purity of water, used by chemists, which are, however, far too elaborate for the ordinary photographer. The following simple tests may, however, be found useful.

1.—Pour about half a pint of water into a wide-mouth bottle or decanter, close it with the stopper or with the palm of the hand, and shake violently up and down. If an offensive odor is then detected, the water is probably contaminated with sewage gas.

2.—Add to a little water a drop or two of dilute sulphuric acid and enough potassium permanganate (Condy's fluid) to tinge it of a faint rose color, and cover the vessel with a glass plate or a saucer. If the pink tinge be still visible after a quarter of an hour or so, the water is probably good.

3.—Pour a little solution of silver nitrate into a carefully cleaned glass, and see that it remains transparent; then pour in some of the water. Should a strong milkiness appear, which is not cleared up on adding a little dilute nitric acid, the water probably contains much sodium chloride.

The purest form of water is obtained by distillation, that is, by first of all converting the liquid into a vapor, and then recondensing it into the liquid form again. (See **Water, Distilled**).

WATER, DISTILLED.—Pure water obtained by distillation. The water is first filtered, and then distilled in a still (*q.v.*) The water which comes out first should be rejected, as it contains nearly all the volatile impurities; and if one-tenth of the water is allowed to remain in the retort the solid impurities are also left.

Distilled water should give no precipitate with silver nitrate, showing the absence of chlorides; nor with ammonium oxalate, showing the absence of lime; nor with barium chloride, showing the absence of sulpuric acid. A drop of potassium permanganate should give a permanent pink tint to the water, proving the absence of organic matter

WATER DEVELOPING PLATES.—These plates are prepared and sold for the conveniences of amateurs and photographic tourists. No developer is required, as the back of the plate is coated with a medium holding the necessary chemicals for the developer; when the plates are immersed in a dish of clean water, this substance at the back dissolves and forms the developing solution.

WATER GLASS.—See **Sodium Silicate.**

WAX.—A term originally restricted to beeswax, but now extended to various bodies possessing similar characters. Found widely diffused in the vegetable kingdom, occurring as a coating on various parts of plants.

Beeswax is the wax of bees, used by them for constructing their cells. It is a secretion elaborated within the body of the animal from the saccharine matter of honey, and extruded in plates from beneath the rings of the abdomen.

It is a yellow, tough, solid substance, insoluble in water, softening with heat, and becoming liquid below the boiling point of water. It may be bleached by exposure to the air in thin shreds.

It is a mixture of several neutral bodies and fatty acids.

Chinese Wax is a secretion from a tree grown in China.

A solution of wax dissolved in benzole or turpentine is used as an encaustic paste for giving a gloss to silver albumen prints.

WAXED PAPER.—To make, place cartridge or other paper on a hot iron and rub it with beeswax, or brush on a solution of wax and turpentine. On a large scale it is prepared by opening a quire of paper flat upon a table and rapidly ironing it with a very hot iron, against which is held a piece of wax, which, melting, runs down upon the paper and is absorbed by it. Any excess on the topmost layer readily penetrates to the lower ones.* Waxed paper is useful for wrapping up sensitive material and preserving it from the effects of moisture and air.

WAXED PAPER PROCESS.—A paper negative process in which the paper was waxed before being sensitized. The waxed paper is immersed in a solution of potassium iodide and bromide, together with sugar of milk, and after drying is treated with a solution of silver nitrate, acidified with glacial acetic acid. After exposure it is developed with—

SOLUTION 1.

Silver nitrate	5 grammes
Glacial acetic acid	8 c. c.
Water	50 c. c.

SOLUTION 2.

Saturated solution gallic acid in distilled water.

For use take equal parts of solutions 1 and 2, with 90 times the bulk of water. If under-exposed a larger quantity of No. 1 is used, and if over-exposed a little more of No. 2. Fixing takes place with the usual solution of hyposulphite of soda.

WAXING NEGATIVES.—With paper negatives the opacity of the paper support is rather a drawback to the positive printing process. To remedy this the paper can be made more transparent. The negative, when quite dry, is laid face down on a piece of blotting paper. An iron is well warmed and cleaned on emery paper or on a clean cloth. A little piece of white wax is brought in contact with the point of the iron, on the back of the negative. The heat will melt a sufficient quantity of the wax, which can then be spread over the picture by moving the iron about in all directions. Blotting paper is next laid over the negative, and the hot iron run over the surface of it until all the superfluous wax is absorbed by the blotting paper. (See also **Translucent.**

WEIGHTS AND MEASURES.—The confusion existing in the English system of measurement is, without doubt, very great. All solid chemicals are sold by avoirdupois weight, while most formulæ are written in apothecaries' weight. Various suggestions have been offered to remedy this state of things. The adoption of the French metric system is, without doubt, but a matter of time.

UNITED STATES WEIGHTS AND MEASURES.

ACCORDING TO EXISTING STANDARDS.

LINEAL.

		Inches.		Feet.		Yards.		Rods.		Fur's.		Mile.
12 inches	= 1 foot.	12	=	1								
3 feet	= 1 yard.	36	=	3	=	1						
5.5 yards	= 1 rod.	198	=	16.5	=	5.5	=	1				
40 rods	= 1 furlong.	7,920	=	660	=	220	=	40	=	1		
8 furlongs	= 1 mile.	63,360	=	5,280	=	1,760	=	320	=	8	=	1

SURFACE—LAND.

		Feet.		Yards.		Rods.		Roods.		Acres.
144 sq. ins.	= 1 sq. foot.	9	=	1						
9 sq. feet	= 1 sq. yard.	272.25	=	30.25	=	1				
30.25 sq. yds.	= 1 sq. rod.	10,890	=	1,210	=	40	=	1		
40 sq. rods	= 1 sq. rood.	43,560	=	4,840	=	160	=	4	=	1
4 sq. roods	= 1 acre.	27,878,400	=	3,097,600	=	102,400	=	2,560	=	640
640 acres	= 1 sq. mile.									

VOLUME—LIQUID.

			Gills.		Pints.		Gallon.		Cub. In.
4 gills	= 1 pint.		32	=	8	=	1	=	231
2 pints	= 1 quart.								
4 quarts	= 1 gallon.								

FLUID.

Gallon.		Pints.		Ounces.		Drachms.		Minims.		Cubic Centimeters.
1	=	8	=	128	=	1,024	=	61,440	=	3,785.435
		1	=	16	=	128	=	7,680	=	473.179
				1	=	8	=	480	=	29.574
						1	=	60	=	3.697

16 ounces, or a pint, is sometimes called a fluid pound.

*Spon's "Workshop Recipes."

TROY WEIGHT.

Pound.		Ounces.		Pennyweights.		Grains.		Grams.
1	—	12	—	240	—	5,760	—	373.24
		1	—	20	—	480	—	31.10
				1	—	24	—	1.56

APOTHECARIES' WEIGHT.

lb. Pound.		℥ Ounces.		ʒ Drachms.		℈ Scruples.		gr. Grains.		Grams.
1	—	12	—	96	—	288	—	5,760	—	373.24
		1	—	8	—	24	—	480	—	31.10
				1	—	3	—	60	—	3.89
						1	—	20	—	1 30

The pound, ounce, and grain are the same as in Troy weight.

AVOIRDUPOIS WEIGHT.

Pound.		Ounces.		Drachms.		Grains (Troy).		Grams.
1	—	16	—	256	—	7,000	—	453.60
		1	—	16	—	437.5	—	28.35
				1	—	27.34	—	1.77

CUBIC OR SOLID MEASURE.

Cubic foot.....1728 cubic inches
Cubic yard.....27 cubic feet

ENGLISH WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT.

20 grains	—	1 scruple	—	20 grains.
3 scruples	—	1 drachm	—	60 grains.
8 drachms	—	1 ounce	—	480 grains.
12 ounces	—	1 pound	—	5760 grains.

FLUID MEASURE.

60 minims	—	1 fluid drachm.
8 drachms	—	1 fluid ounce.
20 ounces	—	1 pint.
8 pints	—	1 gallon.

The above weights are usually adopted in formulæ.

All chemicals are usually sold by

AVOIRDUPOIS WEIGHT.

27 11/13 grains	—	1 drachm	—	27 11/13 grains.
16 drachms	—	1 ounce	—	437½ grains.
16 ounces	—	1 pound	—	7000 grains.

Precious Metals are usually sold by

TROY WEIGHT.

24 grains	—	1 pennyweight	—	24 grains.
20 pennyweight	—	1 ounce	—	480 grains.
12 ounces	—	1 pound		5760 grains.

NOTE.—An ounce of metallic silver contains 480 grains, but an ounce of nitrate of silver contains only 437½ grains.

UNITED STATES FLUID MEASURE.

Gal.		Pints.		Ounces.		Drachms.		Mins.		Cub. In.		Grains.		Cub. C.M.
1	—	8	—	128	—	1,024	—	61.440	—	231.	—	58,328.886	—	3,785.44
		1	—	16	—	128	—	7,680	—	28.875	—	7,291 1107	—	473.18
				1	—	8	—	480	—	1.8047	—	455.6944	—	29.57
						1	—	60	—	0.2256	—	56.96.8	—	3.70

IMPERIAL BRITISH FLUID MEASURE.

Gal.		Pints.		Ounces.		Drachms.		Mins.		Cub. In.		Grains.		Cub. C.M.
1	—	8	—	160	—	1,280	—	76,800	—	277.27384	—	70,000	—	4,543.732
		1	—	20	—	160	—	9,600	—	34.65923	—	8,750	—	567.966
				1	—	8	—	480	—	1.73296	—	437.5	—	28.398
						1	—	60	—	0.21662	—	54.69	—	3.550

CIRCULAR MEASURE.

The diameter is a straight line passing through the center from opposite parts of the circumference, or perimeter.
The radius is half the diameter, or a straight line from the center to the circumference.
The diameter is to the circumference about as 7 is to 22, or more nearly as 1 is to 3.1416.
The diameter × 3.1416 gives the circumstance.
The radius squared × 3.1416 gives the area.
The diameter squared × 3.1416 gives the area of a sphere or globe.
One sixth of the cube of the diameter × 3.1416 gives the solidity of a sphere.

WET COLLODION PROCESS.—See **Collodion Wet Process.**

WET PROCESS.—Synonymous term for the wet collodion process.

WHEY PROCESS.—An old enlarging process by development. Paper is bathed for two or three minutes in

Potassium iodide	2 grammes
Potassium bromide	1 gramme
Whey of milk (filtered)	100 c. c.

It is then hung up to dry, and when thoroughly dry it is sensitized with

Silver nitrate	30 grammes
Water	500 c. c.
Glacial acetic acid	2 to 10 grammes

The amount of acetic acid depends upon the temperature. Exposure is made in a solar camera, the time required varying from about 15 seconds in dull light to one minute with fine.

The developer is made up as follows :

Pyro	3 grammes
Glacial acetic acid	150 c. c.
Water	1000 c. c.
Potassium bromide	1 to 2 grammes

The print is laid on a large glass plate, and the developing mixture poured over it.

WHITE INK.—The following will be found suitable for writing white letters upon the dark portions of silver prints :

Potassium iodide	10 parts
Water	30 parts
Iodine	1 part
Gum arabic	1 part

Chinese white can also be used for the same purpose.

WHITE LEAD.—Made by suspending rolls of thin sheet lead over malt vinegar or pyroligneous acid in closed vessels, the evaporation of the acid being kept up by the vessels being placed in a steam bath or arranged in rows under a manure heap, fermentation producing the necessary rise of temperature.

It forms a dense white powder, insoluble in water, but readily soluble in dilute nitric acid or acetic acid. It is largely used in painting backgrounds and for other similar purposes.

WHOLE PLATE.—The size of dry plate, 8½ x 6½ inches.

WIDE-ANGLE LENS.—A term applied to certain forms of lens embracing a large amount of view. (See **Angle, Wide**).

It should be noted that lenses are often advertised as capable of giving an angle of view of 100 deg. and upwards. They do not do so, however, as, except in the case of certain obsolete forms of lenses, the angle included is rarely more than 80 deg.

In using short focus or wide angle lens a difficulty is often met with by the camera not closing up sufficiently or having too narrow tapered bellows. This can often be overcome by screwing the lens flange on the reverse side of the lens front, and thus fitting the lens inside the camera.

WILLESDEN PAPER.—A peculiar waterproof paper manufactured under a patent at Willesden. This paper, besides being waterproof, will not rot, and will resist the attack of insects or mould.

The process may be briefly described as follows:—The paper is passed through a bath containing a concentrated solution of cuprammonium hydroxide at such a rate as will permit of the pectizing and gelatinizing of the exterior of the fibres composing the paper without wholly disintegrating the mass. It is then dried in the ordinary way. This drying converts the film of pectized cellulose coating each filament and fibre into an insoluble solid varnish which cements the whole together. To build up thick cards two or more reels of paper are passed simultaneously through the bath, and then pressed together and dried as a whole.

Canvas and other fabrics are also treated in this manner.

WILLESDEN TRAYS.—Trays and dishes made with a waterproof substance known as Willesden paper (*q.v.*).

WILLIS'S PROCESS.—See **Platinotype.**

WINDOW ILLUMINATION.—In a dark-room in which daylight illumination is employed the photographer often finds it difficult to regulate the light with the varying intensity of the sun's rays. Thus when the sun is shining directly upon the window the light is dangerously actinic, and requires to be shaded, while at other times we are unable to get sufficient. The most convenient plan for regulating the intensity of the non-actinic light is to employ a light canary-colored glass. If the right color be chosen this is safer than many of the ruby colors which transmit some of the green rays. Outside the window a small Venetian blind arrangement is fitted, the position of the laths being regulated by cords passing into the dark-room. When the laths are placed horizontally we get nearly the whole force of the illumination, while by regulating their angle any desired effect can be produced. The illumination can then be kept at the same degree no matter how bright or how dull the day may be.

WOOD ENGRAVING.—The process of wood engraving has been much simplified by the process of photography. Formerly it was always necessary to employ a skilful artist to draw the image or design upon the wooden block ready for the artist. Nowadays, however, photography is largely employed, photographs being made direct from the negative on to the prepared wooden block, or transferred to it by a transfer process. (For details see **Wood, Photographing on**)

WOOD NAPHTHA.—See **Alcohol Methylic.**

WOOD, PHOTOGRAPHING ON.—There are a variety of processes for photographing upon wood, and for ordinary decorative processes any of them can be used, such as the carbon transfer process, the powder process, transferrotype, etc. But the principal object of producing images upon wood is now usually for the purpose of the engraver. Photography is now rapidly taking the place of the artist on wood. Of the many processes of photographing upon wood only a few, however, can be utilized for this purpose, as they are nearly all defective in one point, and that is that the block becomes wet during the operation. Engravers' boxwood is generally very sensitive to moisture, and to wet a block is generally to spoil it.

The two following methods are given in "Spon's Workshop Recipes":

(1.) From a negative of the subject desired make a clear thin positive upon glass by the wet collodion process. The positive should be of the proper size on clear glass without the substratum. Tone and fix as a transparency, and lay in a dish of water containing a small percentage of sulphuric acid to loosen the film. The film will soon become so loose that it can be easily stripped from the glass and transferred to the block. To do this safely, lay on the film a piece of wet albumenized paper little larger than the glass, press out the bubbles and surplus water carefully, then turn back one corner of the paper, and it will come off bringing the film with it. Have the block smoothly whitened with Chinese white in gum water, and the surface slightly damp. It is now easy to transfer the film to the wood and remove the paper, when the block must be allowed to dry spontaneously.

(2.) Another way to print on wood is by a sort of photolithographic process. Coat paper with a thin uniform coat of gelatine in warm water. Dry, and float a short time on a weak solution of potassium dichromate in water. Dry again, and expose under a negative till all the details are visible. Roll the entire surface of the print with a printer's roller, charged with lithographic transfer ink thinned with spirits of turpentine. Soak the paper in a dish of tepid or warm water until the ink can be removed by rubbing gently with a soft sponge. All the ink, except the lines composing the picture, can be removed: when the print should be laid face downwards on the whitened block, and subjected to a heavy pressure in an ordinary letter press. The paper can easily be removed by wetting the back.

Besides the importance of wetting the block as little as possible, there is another very important point in this branch of the art, *i.e.*, nothing must remain on the surface which is capable of clogging up the point of the engraver's tool, nor must the chemicals used have any deleterious effect upon the wood, causing it to become friable, by which the fine delicate lines crumble and give way under their construction.

Among other processes that have been recommended for photographing upon wood for engraving purposes may be mentioned the following:

In Ives's process thickly-salted albumen is prepared by beating up the whites of six eggs with 80 grains of ammonium chloride. It is then allowed to stand, and afterwards filtered through flannel. A little of this is poured on to the center of the wooden block and mixed with some dry, pure white lead, the mixture is then rubbed into the wood with the ball of the hand. When quite dry it is sensitized by floating on a 60-grain solution of silver nitrate for five minutes, blotted off and placed before a fire to dry. When the block is dry and cold it is fumed for half an hour or so with ammonia, and printed rather deeply under a reversed negative. When printed the block is floated on a large dish of water for an hour or so, changing the water several times, and it is then toned and fixed by floating for half an hour on a ten per cent. solution of hypo, made strongly alkaline with sodium carbonate, and containing a little gold chloride. Finally float for three or four hours on constantly-changed water. If the wooden block is found to be very porous it should be coated two or three times with the albumen solution.

Another method* is with—

Gelatine	45 grains
White soap	45 grains
Water	5½ fluid ounces

Soak the gelatine in the water for five or six hours, then dissolve it with the aid of a water bath, Cut the soap into small pieces, and add to the gelatine solution, stirring the whole with a glass rod to insure a perfect mixture; then add powdered alum until the froth disappears, and strain through muslin. Cover the block with this mixture and a little zinc white, then wipe off so that

* See Spon's "Workshop Recipes.

a very thin film will be left, rubbing it gently so that the film may be of as even a thickness as possible. After drying apply with a wide badger-hair brush a coating of the following:

Albumen	3½ fluid ounces
Water	2½ fluid ounces
Sal. ammonia	67½ grains
Citric acid	19 grains

Whip the albumen to a froth and allow it to settle; to the limpid portion add the water, then the sal. ammonia, stir, and then add the citric acid. When the block is dry, sensitize with a solution of—

Water	3½ fluid ounces
Nitrate of silver	187 grains

Pour this upon the surface of the block, spread it evenly with a glass rod, and pour off the excess. When the block is dry expose under a negative in the usual manner until it is printed the exact shade required. When printed immerse the printed surface in a very strong solution of salt for about three minutes; then wash in a stream of water for a short time, and fix it by placing it face downwards in a saturated solution of hypo. After fixing wash under a stream of water for about ten minutes; when dry it is finished and ready for the engraver.

The American process, said to be the one adopted by the splendidly-illustrated monthly magazines published in this country, is said to be as follows†:

First make a reversed collodion transparency in the camera from the negative. A tough and horny collodion should be used. Develop with—

Pyrogallic acid	100 grains
Citric acid	60 grains
Acetic acid	2 ounces
Water	20 ounces

and fix in hyposulphite of soda. Coat the wood with the following hot solution of gelatine :—

Gelatine	4 ounces
Water	1 pint

Dissolve the gelatine by placing in a vessel of warm water, and then add 4 grains of chrome alum and mix thoroughly. The wood, having been coated, is allowed to dry. The gelatine surface is then moistened with water for ten or fifteen minutes, and the transparency, still wet from the washing water, is laid down upon it and pressed lightly in contact, and allowed to dry under slight pressure. When dry, the collodion readily leaves the glass, and remains in contact with the block

Here are some further points :—The plate is cleaned as usual, and dusted with powdered talc and polished off ; it is then coated with positive collodion, sensitized and exposed as usual, fixed with cyanide of potassium, and placed in a dish of warm water. In the meantime, have your block blackened by rubbing drop black on it, or ordinary blacking, and coat and drain well with a solution of the commonest glue you can get, one ounce to twelve ounces of hot water ; the common glues are the best, for they take a much longer time to set than better ones, and so you can get a much thinner coat with draining. Place your block in a vessel of water, having it immersed about three inches, then bring your photo from the dish, place it over the block and under the water. You will find by touching the edges of the film it will readily leave the glass ; you can then turn it about any way under the water, and when in position, raise your block gently out of the water, bringing the film with it ; if it is puckered at all, it is owing to raising too roughly, and must be placed in the water again. If satisfactory, place at an angle to drain, and dry in warm, airy place. The whole operation, from focusing to getting the block ready for drying, will not take a practised hand more than twenty minutes. The common glue will not block the tool at all if you drain the block well, and when cut all can be removed immediately with a sponge and warm water. A very good way to black the block is to hold it over a petroleum lamp with its chimney removed. The glue-water will not come off it if applied in the same manner as applying varnish to a negative, and under no circumstances be induced to use a black varnish, for it is next to impossible to do a good job, for the graver slips as if it were cutting on glass.

Harris's process does not strictly come under this heading, as an indiarubber block is used instead of wood, but it may be given here, as it is also a process intended as a help to the engraver. Hard rubber is first procured in smooth black polished sheets, about ⅛ in. thick. These are cut and trimmed to the size required, cleaned, and albumenized in the same manner as glass for negatives.

The rubber plate is next coated with collodion, sensitized in the silver bath, exposed in the camera, and developed in the usual way of making a negative. The whole operation is very similar to the ferrotype process, except that the image is made upon rubber instead of iron.

† Wilson's *Photographic Magazine.*

When a clean sharp image is obtained it is fixed in cyanide and varnished with a very thin transparent varnish and dried by a gentle heat. The plate is now ready for the engraver.

WOOD SPIRIT.—See **Methylic Alcohol.**

WOODBURY TISSUE.—A translucent paper coated over with a gelatino-bromide emulsion, and used for the production of negatives, transparencies, etc. This process was the last invention of "that great inventive genius," the late W. B. Woodbury, and had it not been for his death the process would, no doubt, have been brought to perfection. Paper was first rendered translucent by passing through a mixture of gum dissolved in benzole (see **Translucent**), and then coated with an ordinary gelatino-bromide emulsion. Perfect negatives were thus produced upon a material light and flexible, and sufficiently transparent as not to retard the printing operation.

WOODBURYTYPE.—A photo-mechanical process of extreme beauty standing apart from all other photo-mechanical processes, from the fact that it is the only one which faithfully reproduces the half-tones of the picture. Notwithstanding the fact that many unscrupulous persons have laid claim to the invention of this process, it is undoubtedly the outcome of the inventive genius of the late W. B. Woodbury, and to which he gave his name. No one, on reading the description of this process and its apparent simplicity, could imagine the amount of time or labor spent upon its perfection by the inventor, who has been rightly termed "The Caxton of Photography."

The Woodburytype, although much worked in England, is mostly confined to a few firms, owing, probably, to the considerable expense required in the purchase of the necessary plant. For this reason Woodbury devised a simple process, very similar, which he called the Stannotype, but owing to the usual mismanagement of a limited company formed to work it, it did not meet with the success it deserved.

The Woodburytype, or Woodbury process, is also worked to a considerable extent in France, under the name of Photoglyptie, and in Germany as Woodburydruck.

A Woodbury print consists of the same substance as a carbon print. If we examine a carbon print we shall see that the image consists of pigmented gelatine, differing in thickness in the various parts according to the different tints of the image. It is therefore apparent that the image is in relief, the dark parts being raised, and the white parts having hardly any pigmented gelatine at all.

It will not be difficult to understand that if this relief could be obtained, say, by casting the pigmented jelly in a mould, the same gradation of color would be obtained. On further consideration it will also be apparent that, the carbon image being in relief, this might itself be used for the production of the mould. Woodbury's experiments first led him to making negative reliefs from carbon prints by electro-decomposition of copper. But this process was not satisfactory, and moulds were made in plaster, fusible metal, and all sorts of substances, until the inventor discovered the extraordinary hard properties of a gelatine relief, and that it could be pressed into lead, or even harder metals if necessary, forming the necessary mould as perfect as was possible to be obtained.

The next difficulty was that the carbon print, although possessing sufficient relief while wet, could not be pressed into the lead in that state, and when dry the amount of relief was reduced to a fraction of the amount when wet. It therefore became necessary to secure some method of obtaining a very high relief. This was eventually managed by having a very thick film of best chromated gelatine, having but a very slight amount of pigment in it, enabling the light to penetrate it the more easily.

Prof. Burton, in his excellent work on photo-mechanical printing processes, says:—"When the Woodburytype process was first worked the difficulty in getting a sufficiently high relief was much felt. At that time paper was not to be had nearly as smooth as it can now be obtained, and with a comparatively slight relief faults in the paper showed very plainly. It is now, however, possible to work with a relief in the final print of only $\frac{1}{200}$ of an inch or even less, and as the relief of the print shrinks in drying by about ten times, this involves in the mould a relief of only about $\frac{1}{20}$ of an inch, which is one that is not difficult to get if due precautions be taken. It will be evident that it is necessary to begin upon a film at least as thick as the relief required, and that initial thickness of film being sufficient, the depth or height of relief will be greater the greater the contrast in the negative and the less the amount of pigment in the film. Indeed, the pigment may be left out altogether when a negative of only moderate density has to be worked with."

With regard to the negative most suitable for the Woodburytype processes. Like most other photo-mechanical processes, a "brilliant" negative full of contrast is essential, having at the same time all the necessary gradation between the two extremes, and also possessed of plenty of detail. The negative for the purpose is, whenever possible, made by the collodion process. Good gelatine negatives can be used however. From a thin gelatine negative it is rare that a good Woodburytype is producible. It can sometimes be improved by making a transparency from the thin negative on a very slow bromide or a chloride plate, intensifying this and making another negative from this, the latter being also intensified if necessary.

The next consideration is the production of the gelatine relief. For this we first require to prepare the sensitive tissue. Several formulæ have been given. The following has been chosen, however, and will be found to give satisfactory results.*

Nelson's transparent sheet gelatine	3½ ounces
Sugar	1 ounce
Glycerine	100 grains
Phenol	2 minims
Indian ink	2 grains
Ammonia (.880)	60 minims
Bichromate of ammonia	300 grains
Water	12 ounces

The gelatine is first of all soaked in 10 ounces of the water, and the Indian ink dissolved in the remainder. When the gelatine is thoroughly soaked, it is melted by the aid of gentle heat, and when dissolved the sugar, glycerine, phenol, and ammonia are added. The Indian ink solution is then poured in, and finally the bichromate of ammonium is stirred in in a finely powdered state.*

*Another formula is the following:—

Nelson's gelatine	4 ounces
Sugar	½ ounce
Glycerine	100 grains
Phenol	2 minims
Indian ink	2 grains
Potassium bichromate	200 grains
Water	12 ounces

While this solution is being prepared, sheets of patent plate glass, somewhat larger than the size of the print required, are thoroughly well cleaned. A tuft of cotton wool dipped in powered talc or French chalk is then rubbed over one side, and dusted off again with a fresh piece of cotton wool. The chalked side is then coated with a film of plain collodion, and placed away to dry spontaneously.

We now have the collodionized plates and the solution ready, and the next operation is to gently warm a plate, and, placing it on a level stand, carefully adjust it with a spirit level. When this is done a measured quantity of the gelatine solution, previously heated to about 130° Fahr., is poured and carefully spread all over the plate. The amount of the solution to be used is about half an ounce for each quarter plate, or about five ounces per square foot. The operation of coating can be performed in diffused daylight, as the films are not sensitive until dry, when they must be carefully protected. As soon as the film is set the plate is removed to the drying chamber. On account of the thickness of the film a special drying arrangement is used in which slightly heated air is made to circulate, firstly over the dried calcium chloride and then over the films. The effect of this is that the calcium absorbs all the water from the air, which then greedily absorbs the water from the films. Fig. 490 shows an arrangement given in the *Photographic News*. The direction of the arrow shows the passage of the air. The calcium chloride should be well dried by heating in a shovel over a bright fire. It can be used over and over again if dried in this manner previous to use. A little thermometer should be attached to the drying box, with its bulb in the interior of the box, and the scale outside so as to be easily read without the necessity of opening the chamber. The temperature should be raised to about 80° Fahrenheit but never allowed to exceed 85°.

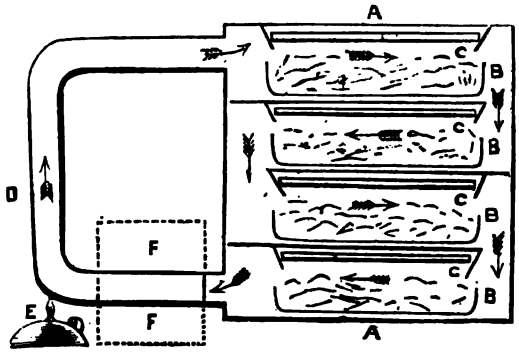


FIG. 490.—DRYING CHAMBER.

As soon as the films are quite dry they are cut all round the edges with a sharp knife and separated from the glass support. They are then carefully protected from light and moisture by wrapping in non-actinic paper and then in tinfoil. The best effects are obtain by using the films at once, or at least within two days from preparation.

Before printing from the negative it should be provided with a "safe edge," as in carbon printing. It is then placed in the printing frame, and the collodionized side of the film laid next to it. A sheet of tinfoil, or a plate of glass, is then laid over the film to protect it from moisture, and the frame carefully closed.

With regard to the exposure, an actinometer is, of course, required, as with the carbon process. The exposure is, however, somewhat longer, even after allowing for the density of the negative usually used. Printing can be carried on advantageously in full sunshine provided that the frame be kept at right angles to the directions of the sun's rays. The exposure is thus, of course, considerable lessened. When only a small amount of pigment is used in the preparation

* From *Photographic News*, September 14th, 1883.

of the film the image is slightly visible; it is not however, advisable to open the frame for the purpose of examining it, as the tissues might be attacked by moisture and thus become insoluble.

After exposure the next operation is to develop the film in the same manner as a carbon print. First of all, however, it is necessary to have some support to hold the film during the development, otherwise it would soon become unmanageable. For this purpose a sheet of glass coated with an indiarubber solution has been found most suitable. A very thick rubber solution is sold in tins. This is diluted with pure benzine until it flows similar to collodion. The glass plates are coated with this solution in the same manner as with collodion, except that as little excess is poured off as possible. The plates when coated are laid on a levelling stand until the rubber becomes tacky. When it has arrived at this state, which may require an hour or so, the collodion side of a film is laid in contact with it in such a manner as to prevent the formation of air bubbles between the two surfaces. This is done by bringing one edge into contact first and gradually laying it down. The next thing is to ensure perfect and close contact by rolling through an ordinary indiarubber roller wringing machine, or if such an instrument be not at hand, any metal or other rolling machine can be used by placing two thick pieces of sheet indiarubber, one above and one beneath the plate, to prevent the glass from breaking.

The development of the image next occupies our attention. This is done with hot water only, the plate being kept in a vertical position under the water. Usually a number of plates are developed at the same time in a metal grooved box. Development must be allowed to proceed spontaneously, and is sometimes completed in a couple of hours, or may require a day, or even longer. The temperature of the water should first be no hotter than 100° or 105° Fahr., and this should be frequently changed.

When all the bichromate salt has been been dissolved out, and the water remains colorless, the temperature is gradually raised as required to perhaps as much as 150°. The plate can be removed from time to time, and the progress of development examined. If pigment was used in the film, the image will appear as a transparency, but if not, it is only possible to judge by the amount of relief in the film. In a correctly-exposed and developed relief, those portions of the film which represent the high lights should be washed away very nearly to the collodion, and at the same time dark parts forming the highest relief should still represent very nearly the whole thickness of the film, that is to say, only a small quantity of gelatine should have been dissolved away from these parts. From this it will be easily possible to judge whether the film has been exposed correctly. If over-exposed, parts of the film will retain the original surface, no gelatine having been dissolved away at all from these parts, while on the other hand, if the exposure has been too short, a large quantity of gelatine will be dissolved away, leaving a poor, weak relief. The effect of using the over-exposed relief would be the production of prints with heavy, dark shadows, while the under-exposed relief would produce poor or sickly-looking prints. It will readily be understood, therefore, that considerable practice and skill are required in judging the correct exposure, and that a great deal depends upon this in the production of perfect prints.

As soon as the development of the film is considered complete, the plate is held under a cold water tap for a few seconds, and well rinsed all over. It is then laid in a five per cent. solution of chrome alum for about eight or ten minutes, so as to make it as hard as possible. After this the film is well washed in cold water to remove the alum, and then stood on end on a piece of blotting paper for a few minutes to get surface dry. The next operation is to lay it in a dish containing methylated spirits, and to allow it to remain in this for about an hour or so. It is then placed in a rack to dry spontaneously. As soon as the film is dry* it can be removed from the glass by inserting a penknife under one corner, and gradually and gently drawing it away. The whole or parts of the rubber will come away with it, and this is next removed with the tip of the finger, the rubber being made to come off in little rolls and balls.

The relief can now be retouched. Any little spots or marks which are raised in the relief, and which would print dark in the final image, can be removed by scraping gently with the edge of a strip of glass broken square across. A relief can often be considerably improved in this manner, although it is needless to say some skill and knowledge are required.

The relief is now ready to be used for the production of the leaden printing moulds, but it is always advisable to keep it for a few hours after stripping from the glass. The reason of this is that the relief contracts slowly for several hours after removing from the glass plate, and until it has arrived at its normal condition it is very liable to break when under pressure. Reliefs are usually stored away in albums, each relief being attached to a page by its four corners stuck through four slits in the leaf. It is thus easily removed, and, if the book be indexed, any desired relief can be quickly found at any time.

From this gelatine relief we can at any time, produce the printing mould. All that is necessary is to press the relief down on to a sheet of lead with sufficient pressure to drive it into the metal, and thus form a perfect mould. As, however, the pressure required is very great, being nearly five tons per square inch, the machine necessary for this work is naturally very expensive, and it is this fact that has prevented the process from being more generally employed. An hydraulic press for pressing sizes up to whole plate would require to be capable of being worked

* Some operators prefer to remove before it is quite dry, as otherwise there is a danger of the collodion cracking.

up to 250 tons. This size is about the largest usually employed in this process owing to the enormous amount of pressure required. Special presses have been constructed for the Woodburytype process by Messrs Tangye Bros., which are very compact, the length of stroke being very small. Besides the press we require a steel plate perfectly planed and scraped as a surface plate, with pieces of steel bolted all round the sides to prevent the lead from spreading out when subjected to pressure. Fig. 491 and the following description* will better serve to illustrate the matter:—"A is the steel plate, BBBB are the steel bars, which may be ½ x ⅜ inch in section, slightly bevelled away at the inner edge as shown. They are fixed with set screws. C is the lead plate, polished on its lower side, and smooth on both sides. The platen of the machine is made just to fit within the bars BBBB, so that when it comes down it cuts off the edges of the lead plates. The relief is placed on the plate A, the lead plate is placed in position as shown, one or more thicknesses of millboard are placed on the top of it, the platen is brought down with full pressure, and when it has been raised, and the lead is removed, it will be found that a perfect mould has been produced, and these may be multiplied almost indefinitely.

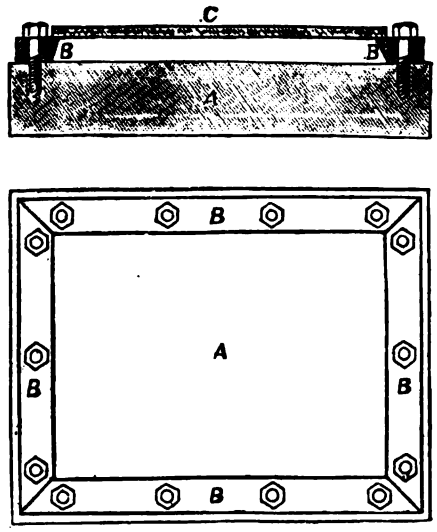


FIG. 491.

It should be noted that the best moulds are produced when the relief is laid upon the plate collodion side downwards; but a little consideration will show that if this be done a reversal print will be produced. It is therefore always advisable to find some opportunity during the different processes to reverse the negative image. If this be not possible the relief must be laid on the plate with the collodion side uppermost, and two or three moulds made and rejected. After this the moulds following will be as sharp as required.

The mould is now trimmed round the edges with a circular saw, cutting off all the superfluous lead except a margin of about half an inch round the picture. It has already been shown how the operator with a little strip of glass can plane away any little raised defects in the relief. Those which he cannot do, however, he can in the mould, as they are then raised, and will allow of being removed.

The operation of printing is practically the production of a number of castings from the lead mould or gelatine containing a suitable pigment. The mould is placed upon the bed of the printing-press, a little pigmented gelatine solution poured on to it, a sheet of paper laid over this, and the lid of the press is then brought down. By the application of pressure all the excess of gelatine solution is squeezed out round the edges, and only that remains which lies in the hollow parts of the mould. This sets, and at the same time adheres to the paper only (the mould being slightly greased), and a perfect casting of the mould is obtained adhering to the paper. This casting is, of course, in relief, the dark parts standing rather high, and the other shades of varying thickness, thus giving perfect gradation. When dry the amount of relief is scarcely discernible, but the different tints remain the same.

It must not be supposed that any kind of paper will do for printing upon, as it requires to be perfectly smooth and of even texture, and to be specially prepared for the purpose. A paper very suitable is that known as Rives, which is manufactured specially for photographic purposes. A kind of varnish is made up as follows:—

Borax	4 ounces
Sodium carbonate	1 ounce
Water	3 pints

This solution is heated to boiling point, and then is added—

White shellac	1 lb.

The mixture is kept boiling until all the shellac has dissolved. When quite cold, water is added to make up to its original volume. A little carmine is also added for the purpose of giving an agreeable tint to the pictures. It also has the advantage of rendering the coated side of the paper easily distinguishable. The paper is coated in a room kept warm, the temperature not being allowed to fall below 90° Fahr. The solution is first of all filtered, and then poured into a deep dish in such a manner as to avoid the formation of air-bubbles. A piece of wood is placed under the farthest end of the dish to incline it a little, and so give it a greater depth of liquid at that part of the dish next the front edge of the table and nearest to the operator. Two sheets of the paper are now placed back to back, and held by two opposite corners, keeping the edges in perfect contact with each other. With one clear sweep this double edge is immersed in the shallow end of the liquid, drawn along the solution, and brought out of it at the deep end. At first thought one would imagine that the liquid would run between the two sheets, but this is not so,

* Burton's "Photo-mechanical Printing Processes."

however. The density of the liquid keeps them tightly together, only penetrating about the one-sixteenth of an inch all round the edges. After the sheets are brought out of the liquid they are allowed to drain a little into the dish, only care must be taken to hold the bottom edge as near to the surface of the solution as possible to avoid air-bubbles. They are then hung up to dry. When dry, the two sheets are separated from each other by cutting off a slip about one-eighth of an inch from one edge, and inserting a penknife to separate the other edges. The sheets thus separated are laid one on top of the other ready for the next operation. An emulsion of gelatine and resinous matter is prepared by dissolving one part of gum benzine in 10 parts of alcohol. This solution is filtered, and mixed with a warm solution composed of one part of gelatine, dissolved in nine parts of water, violently stirring the whole while the addition is being made. This solution is applied to the surface of the lac-coated paper, by means of a piece of soft flannel made in the form of a pad. It will be found sufficient to thoroughly moisten the surface, and set it aside to dry. When dry the prepared paper is required to have a glass-like surface given to it. This is done by passing a set of alternate sheets of paper and thin highly polished steel plates through a powerful rolling press. After the paper has been prepared and rolled, it requires to be handled with extreme care, as any little crease will show in the finest print.

We have now considered the production of the printing mould and the paper, and must now give our attention to the printing press. What is really required is an arrangement that will press the paper perfectly flat upon the mould, and drive out all the superfluous gelatine ink. The presses used by most firms working the Woodbury process are heavy, clumsy arrangements. That designed for the Stannotype process, and depicted in Fig. 000 answers the purpose equally well. It would be as well to note here that the process of printing hereafter described, is the same in the Stannotype process as in the Woodburytype. The production of the mould by the former process is described under **Stannotype.**

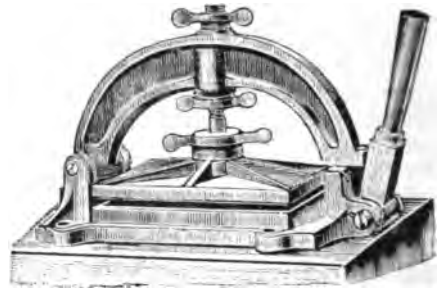


FIG. 492.—PRINTING PRESS.

With regard to the printing process, it will be seen on reference to Fig. 492 that it is not unlike an ordinary copying press, except that the arch is hinged at one end and clamped at the other. By means of the three nuts the platen of the press can be adjusted to any position and held tightly. The bottom nut serves to screw up a ball-and-socket joint used to adjust the angle of the platen, in case of a want of parallelism between the two faces of the mould, and the other two serve to adjust the distance between the bed of the press and the platen according to the different thicknesses of mould. The pressure is also adjusted to any desired amount, and this always repeated every time the arch is lowered.

To prepare for printing, the arch is raised and pushed back out of the way. A piece of wet cardboard is then laid on the bed of the press, and upon this the Woodbury or Stannotype mould is placed.* The three screws are now loosened and the platen brought down upon the relief. The surface of the plates consists of a thick piece of glass cemented to the ironwork, and ground perfectly true. This should lie perfectly true upon the mould. The handle which clamps the arch is then adjusted. The screw beneath the arch is now screwed up tightly to adjust the pressure. The top screw is then tightly adjusted. The bottom screw holding the ball-and-socket joint is now turned tightly. If all the screws have been properly adjusted, the platen should be so rigidly fixed to the arch that it will always come down in precisely the same position, and with the same amount of pressure.

The ink used in printing is composed simply of gelatine dissolved in water, and a little coloring matter added. The gelatine should be of a hard kind ; Nelson's opaque, or Heinrich's hard emulsion gelatine both answer the purpose admirably. The proportions are about one part of gelatine in five parts of water, but in very cold weather this may be found too stiff, and a little water and more pigment added. The amount of coloring matter to be added to the gelatine solution to form the printing ink can only be satisfactorily found by experiment. Of course, any color can be used, but, as a rule, Indian ink and a little carmine is added. The amount of color required varies with the depth of the mould, the deeper the mould the less color being required. The best plan is to make up the gelatine solution, add a very small quantity of coloring solution, and make a print, a few drops of coloring matter being added each time, until the best effect is produced. To save trouble in grinding the color, liquid Indian ink can be purchased. Mr. Geo. Smith, an authority on Woodburytype printing, recommends "lamp brown," obtained by collecting the smoke from the tip of the flame of a small lamp burning benzine. It gives a very rich color, and has the advantage of permanency. He also adds a small quantity of bichloride of mercury to the ink, to prevent decomposition. The ink is usually kept in thin glass sloping necked bottles, this shape being most convenient, as the ink can be poured out with but little chance of air bubbles forming. The flask containing the ink is kept in a bath containing warm

* With a Woodbury or lead mould the better plan is to soften a piece of gutta percha in hot water and press it between the platen of the press to a sheet of about a quarter of an inch and this will form a perfect bed for the leaden mould.

water, and to this it is returned after every time of using. The mould is first greased by rubbing it over with a piece of flannel containing a few drops of a mixture of paraffin and salad oil. The smallest quantity is sufficient; any excess must be carefully avoided. The next operation is to pour a little pool of the warm gelatine ink on to the center of the mould. The size of the pool should be about half the diameter of the picture. A piece of the paper is next laid on this, prepared side downwards, and the platen of the press brought gently down and clamped firmly with the lever handle. The excess of gelatine is thus squeezed out, and runs down the bed of the press into the trough round the bottom, from whence it can afterwards be removed and used over again. After closing the press, a few minutes are allowed to elapse for the gelatine to set. In winter or in cold weather the gelatine does not require a very long time to get stiff, but in summer it may take some time. In very hot weather it sometimes becomes necessary to work in a very cool room, or to use ice round the press to keep it cold. In works where large quantities of printing are done the presses are arranged round a circular table, which revolves round its central support see Fig. 493. The printer stands at one place, opens one press, pours the ink on, places the paper on this, closes the press, and gives the table a slight turn until the next press comes into position before him. This is filled up and moved on, and this repeated until the press first manipulated has completed the circuit and again comes before the operator. By this time the gelatine ink has had ample time to set, and the finished print is lifted away, fresh ink and paper put on, and the press again closed, and so on. Thus no time is lost, the prints being made as fast as it is possible for the printer to work the presses.

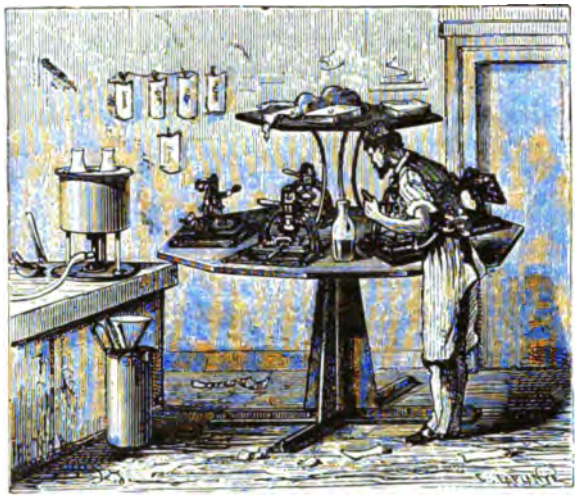


FIG. 493.—TURN-TABLE REQUIRED FOR PRINTING WOODBURYTYPES.

When the first print is made it must be carefully examined to find out—first, if the press is properly adjusted, and secondly, if the ink is correctly prepared with regard to density and color. If the margins of the print are not clear and white, either the pressure is insufficient or the gelatine is too strong. The pressure should be increased by loosening the top screw, and screwing up the one directly underneath the next more tightly than before, and then tightening up the top screw again. If no improvement takes place the ink is probably at fault and should be diluted with water. If the image is too light all over, more coloring matter should be added, but if it shows clear margins, and is generally too dark, too much coloring matter has been added, and more gelatine and water should be mixed with it.

As soon as the press has been properly adjusted with the requisite amount of pressure, and the ink properly mixed, printing can proceed regularly without any trouble. The oily cloth should be rubbed over the mould every two or three impressions, or oftener if the gelatine is found to stick. In removing the prints one corner is laid hold of and the print drawn slowly away. The thick edging of gelatine all round the margin is scraped away with an artist's palette knife, with the rounded end cut off straight. The ink scraped off and all that which finds its way into the trough of the press and round the sides of the mould, is all collected and can be melted up again and filtered ready for use.

Before the prints are dried they are immersed in a three per cent. solution of chrome alum for about five minutes. The effect of this is to harden the gelatine, rendering it insoluble and less likely to be influenced by moist atmospheres. After treating with the alum bath the prints are well washed in water and permitted to dry spontaneously. When dry the brilliancy of the surface can be improved by rolling on a polished steel press, or by rubbing with an encaustic paste, or a varnish composed of—

Borax	4 ounces
Water	3 pints
Shellac	8 ounces

and dried in front of a fire.

The softness and beauty of the Woodburytype process is not equaled by any other process. For portrait work it is especially suitable. One of the drawbacks, however, is the difficulty of obtaining large, clean, white surfaces; thus, in landscapes, a sky must be printed in, or else the gelatine ink wiped away directly after printing by means of a rag dipped in warm water. For the same reason vignettes cannot be printed. For many years the difficulty of obtaining clear white margins was keenly felt, it being always necessary to mount the pictures upon a suitably stiff paper, and this in the case ot book illustrations was very objectionable. Recently, however,

it is pleasing to note a method has been devised by means of which the ink can be entirely removed from the margins, leaving a clear image in the center of a piece of white paper. The method as yet remains a secret, no particulars having been divulged. Another process has also been devised, by means of which the prints are transferred to another paper, or other support. Clear margins are thus obtained, and a soft matt appearance given to the image.

It must not be omitted to be mentioned that besides the production of paper prints the Woodbury process is largely employed in the manufacture of opals, lantern slides, etc., of superb quality.

WOOD NAPHTHA.—The neutral crude distillate obtained from the products of the destructive distillation of wood. It contains from 75 to 85 per cent. of pure wood spirit or methylic alcohol, 5 to 10 per cent. of acetone, with much smaller proportions of creosote, aldehyde, hydrocarbon oils, and other substances that are but little known. In its most rectified condition it possesses a specific gravity of ·830.*

WORTLEY'S PROCESS.—A dry collodion process invented by Colonel Wortley, in which the following is used as a preservative:

SOLUTION NO. 1.

Salicine, saturated solution in distilled water.

SOLUTION NO. 2.

Tannin	60 grains
Distilled water	1 ounce

SOLUTION NO. 3.

Gallic acid	48 grains
Alcohol	1 ounce

To make the preservative take

No. 1	2 ounces
No. 2	1 ounce
No. 3	½ ounce
Sugar	40 grains
Water	7 ounces

This can be used over and over again with occasional filtering. The plates are immersed in it.

WRITING INK PROCESS.—See **Ink Process.**

X RAYS.—One of the most remarkable discoveries of the present century was that made by Prof. Roentgen. He discovered that certain rays (which for want of a name he calls X Rays) emanating from a Crookes vacuum tube have the same effect upon a photographic dry plate as light. Moreover, these rays will penetrate all kinds of substances, such as a block of wood twelve or more inches thick, with the greatest ease. Other substances, such as metal, bone, etc., were less transparent. The value of this discovery to the surgeon is a very great one, as can easily be imagined. Fig. 495 shows an X ray photograph or Radiograph, as it is called, of a foot encased in a shoe.

The method of making these Radiographs is shown in Fig. 494. The photographic dry plate is inserted in an ordinary plate-holder and the objects to be radiographed laid on the outside. In the sketch shown on the holder was laid a pocketbook of dark Russia leather, with several flaps of leather within, and containing seven cards, two of them thick. A number of coins were slipped into the inside compartment of the book, which was then closed and laid upon the board under the tube.

On the plate, when developed, only a faint shading was left by the pocketbook, see Fig. 496, but the coins left a strong and definite picture, showing with surprising clearness their number and position in the book. A trace of Prof. Wright's hand, which rested upon the board during this experiment, was also strongly depicted. The outlines of the hand are somewhat blurred, and in the palm faint traces of the passage of the rays between the bones could be detected.

YELLOW FOG.—See **Fog.**

YELLOW STAIN.—A yellow stain is often produced upon negatives caused by insufficient fixing. This is very often difficult to remove. One method recommended by Mr. Drake is as follows: Soak the plate for five minutes in clean water, meanwhile make a solution of iodide of

* Hunter's "Encyclopedia Dictionary."

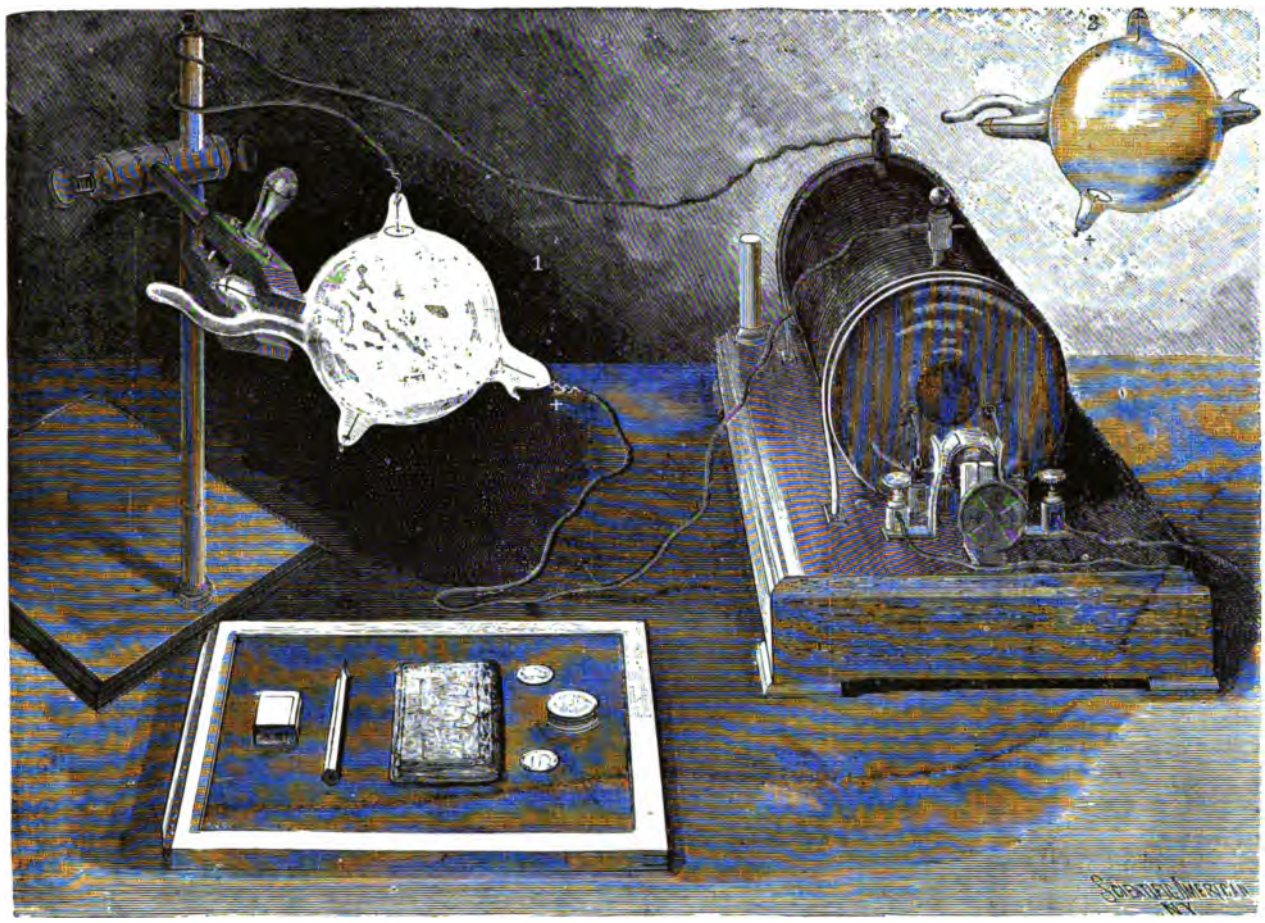


FIG. 494.—SHOWING METHOD OF USING X RAY APPARATUS.

potassium, twenty grains to the ounce of water, now put the plate in this solution and let it stay for ten minutes. If the stain is very old keep it in for half an hour. Now dissolve half a drachm of cyanide of potassium in one ounce of water. Take the plate and put into this, and gently rub the stains with a tuft of cotton wool (absorbent filtering cotton will do), free from grit, until they are quite gone. If the stains are very old, make the solutions stronger and soak for a longer time.

Yellow stains are also often produced by pyro-development. These can usually be removed by immersing the plate in a clearing solution composed of

Alum	4 ounces
Citric acid	2 ounces
Water	20 ounces

for several times. In this solution the plate should be soaked for about ten minutes in water before immersing in the above.

Yellow silver stains produced in printing from ordinary silver paper can be removed with the following:

SOLUTION A.

Sulphocyanide of ammonium	½ drachm
Water	1 ounce

SOLUTION B.

Nitric acid	½ drachm
Water	1 ounce

For use, mix equal parts of A and B fresh for each negative, and apply to stained portions, or the negative can be immersed in the solution. After the stain has disappeared the negative should be well washed, and treated with a saturated solution of chrome alum and well washed.